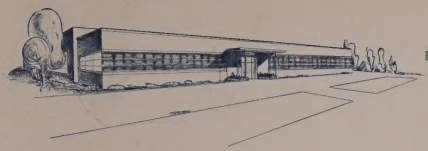

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INSTRUCTION MANUAL

MODELS 7360 & 7350J
UNIVERSAL EPUT® AND TIMER

INDUSTRIAL AND NUCLEAR INSTRUMENTS

ANALOG COMPUTERS

FIELD TRAINING
SECTION

Berkeley division
BECKMAN INSTRUMENTS, INC.
2200 WRIGHT AVE., RICHMOND, CALIF.
TELEPHONE: LANDSCAPE 6-7730

WARNING

Do not attempt to operate this instrument until you have read the Instruction Manual.

INSTRUCTION MANUAL

MODELS 7360 & 7350J
UNIVERSAL EPUT® AND TIMER

Lot and above

NOTE

IF MODEL NUMBER IS FOLLOWED BY AN INKED-IN LETTER, THE INSTRUMENT THIS MANUAL ACCOMPANIES HAS BEEN MODIFIED. IF SO, SEE SECTION SIX ON MODIFICATIONS BEFORE READING FURTHER.

BERKELEY division
Beckman Instruments, Inc.

20 February 1956

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.

(b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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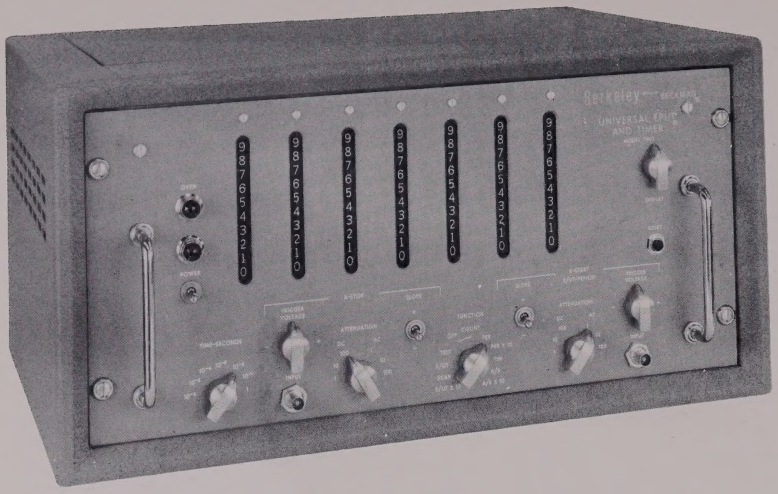
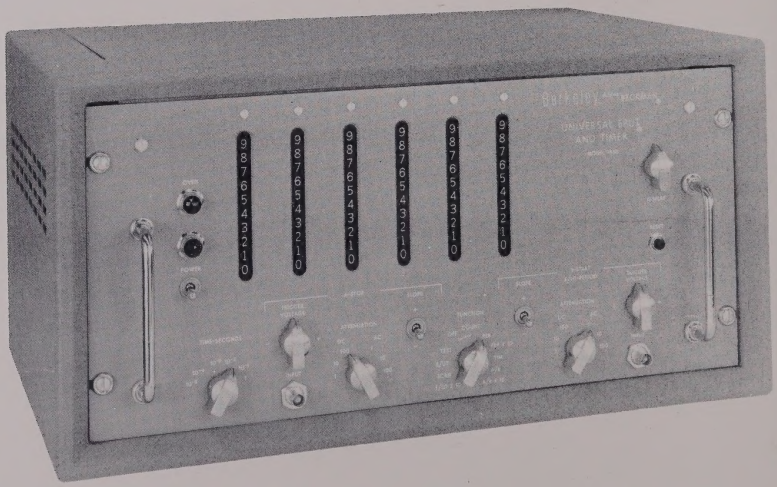
Model 705AH,AJ Decimal Counting Unit

Model 707AH Decimal Counting Unit



Model 7360



Model 7350

1 Introduction

DESCRIPTION

The Universal EPUT* and Timer, Models 7360 and 7350, is an electronic counter which will perform a wide variety of frequency and time measurements. These various functions are described below under "SPECIFICATIONS". The instrument consists of a precision clock-pulse generator, two input pulse-forming (trigger) channels, an electronic gate and a chain of decimal counting units (DCU's). When measuring frequency, each input signal cycle triggers a sharp voltage pulse on one of the input channels. These pulses pass through the gate and are counted by the DCU's during a precise time interval established by the clock-pulse generator. When measuring time, clock pulses are let through the gate and counted during a interval controlled by input signals.

The Model 7360 differs from the Model 7350 primarily in the highest frequency which may be measured and in the smallest unit of time measurement available. The Model 7360 will measure frequencies as high as 1MC, whereas the Model 7350 is limited to 100KC. The Model 7360 will make time measurements in one-μsecond units while the smallest unit of time measurement on the Model 7350 is 10 μseconds.

SPECIFICATIONS

FUNCTIONS

1. Measures frequency or counts events-per-unit-time over a maximum automatic time interval of 10 seconds with a manual extension beyond 10 seconds for extreme accuracy.
2. Measures period of a wave or the width of a pulse. Measures ten periods when greater accuracy is desired.
3. Measures the time interval between two events represented by pulses on separate input channels. When a signal is applied to one channel and the same signal in a different phase to the other channel, the result of this measurement is the phase difference.
4. Counts the number of events occuring between two events represented on the same input channel. If the events to be counted are cycles of a signal of one frequency and the two events which begin and end the counting period are successive cycles of a lower frequency, the result of this measurement is the ratio of the frequencies.
5. Counts events over a manually controlled time interval.
6. Makes self-check on accuracy of clock signals and Decimal Counting Units.
7. Performs any of the above functions with an external frequency substituted for the internal oscillator frequency.

* Trademark Registered U. S. Patent Office.

PERFORMANCE CHARACTERISTICS

Input Trigger Channels

Input frequency range
d-c to 1MC

Input impedance
10 megohms in parallel with 40 $\mu\mu$f

Input sensitivity
100 millivolts rms, 0.3 volts peak-to peak from d-c to 1MC

Input voltage attenuation
1, 10 or 100 a-c and d-c

Overload limits
Input impedance drops below 10 megohms when input voltage rises above +1 volts d-c after attenuation.

Trigger voltage level
Adjustable from -1 to +1 volts at the attenuated signal

Trigger slope
Plus or minus

Clock-pulse Generator

Output frequency
Selectable in decade steps from 1 cps to 1MC on the Model 7360 and from 1 cps to 100KC on the Model 7350

Output signal
0.25 μseconds pulse 5 volts high out of 5000ohms, available for external use.

Oscillator Stability
Model 7360: 2 parts in 10^7 per week
Model 7350: 1 part in 10^6 per day

Gate, Control Circuits and DCU's

Resolution
Model 7360: 0.8 μseconds
Model 7350: 5 μseconds

Capacity
Model 7360: 10^7 counts
Model 7350: 10^6 counts

Display
Continuously variable from .05 to 5 seconds.

4-line code from DCU's to external connector

APPLICATIONS

The Universal Eput and Timer can be used to make a wide variety of frequency and time measurements both in the laboratory and on the production line. It is useful in designing transmitters, receivers, tuned circuits, crystals, oscillators and other equipment which must have definite frequency characteristics. On the production line the instrument is ideal for making stability checks on transmitting and receiving equipment and on crystals during heat cycling. It may also be used to calibrate less accurate frequency monitoring equipment.

Various transducers such as photocells, magnetic pickups and switches may be used to produce voltage changes representing physical events. So equipped, the instrument will measure the characteristics of such events relative to time. Some of the known applications of the instrument are:

Frequency measurements
Frequency ratio measurements
Relay and switch timing
Phase measurements
Viscosity and ballistic measurements
Elasticity measurements
Tachometry
Telemetery
Pulse height analysis
Oscilloscope time base calibration
Use as a secondary frequency standard

The versatility of the instrument can be fully utilized only when it is equipped with the proper accessories. Numerous transducers such as the Model 442 Reflecting Tachometer as well as sev-

eral data recording and data reduction instruments are available at Berkeley. The Model 1452 Digital Recorder, designed for use with this instrument, converts count information into a printed record. The unit prints the count accumulated by the counter during each counting period. The printed count appears sequentially in Arabic numerals on a standard adding machine tape. This recorder is ideal for making long term stability checks, recording transients, monitoring, or for making a permanent printed record in control or measuring systems.

The Model 1440 Series, Data Reduction Converters, convert digital information from the counter to a form suitable for actuating an IBM summary punch or an electric typewriter. These converters have uses similar to those of the Digital Recorder. The Model 1440S is designed for use with the IBM Summary Punch Type 523; the Model 1441S, for use with the IBM Summary Punch Type 615, and the Model 1442S, for use with an electric typeweiter. On special order Berkeley will prepare a modification of the Model 1442S which will drive a teletype or a microwave link. In this way count information may be made instantaneously available at various remote locations.

The Model 1445 Digital to Analog Converter converts the count accumulated during each counting period to a representative voltage level. This voltage is held until a new count is completed when it changes to conform with the new count. The unit may be used with a self-balancing potentiometer to provide an analog record, or the changing voltage level may be used to control the operation being monitored.

With the exception of the modified Model 1442S, the instruments described above are standard accessories. Other converters, transducers and special equipment may be ordered to meet specific problems.

2 Operation

OVER-ALL DESIGN

The counter will make three types of measurements aside from simple counting.

1. It will count the number of events occuring during a precise time interval. This is known as Events-Per-Unit Time or E/UT Operation. Frequency measurements are made in this way. The SCAN function is a variation of this operation.
2. It will measure the time interval between two events. If the two events are represented by voltage changes on separate input channels, it is called Time-Interval-Measurement or TIM Operation. If the two events are represented on the same input channel this is known as PERIOD Operation.
3. It will count the number of events occuring between two other events. This is Ratio or A/B Operation.

If the events mentioned above are not initially voltage changes, appropriate transducers are used to produce voltage changes representing the events at the counter INPUTS. Two input trigger channels within the counter convert the voltage changes they receive into sharp pulses. A clock-pulse generator in the instrument produces similar pulses separated by a precise time interval. Besides these three pulse sources the counter contains an electronic gate and a chain of decimal counting units. (DCU's). The DCU's count and indicate the number of pulses which pass through the gate between a start pulse which opens it and a stop pulse which closes it.

The FUNCTION switch determines the type of measurement made by selecting the pulse source which provides each of the three signals -- pulses to be counted, the start pulse and the stop pulse.

1. Under E/UT Operation one of the input channels provides pulses which are counted over the known time interval between start and stop pulses from clock-pulse generator. With the proper placement of a decimal point the lighted DCU's indicate events or cycles per second.
2. Under PERIOD or TIM Operation pulses of known frequency from the clock-pulse generator are counted over an unknown interval between start and stop pulses from one or both of the input channels. Since the clock-pulse frequency is equal to the 1MC or 100KC oscillator frequency divided by a power of 10, the time measurement appears directly in decimal fractions of a second.
3. Under A/B Operation pulses from one of the input channels are counted between start and stop pulses from the other channel. If the events represented by the pulses are cycles of input signal waves, the DCU's indicate the number of cycles at one input which occur during one cycle at the other INPUT or, in other words, a frequency ratio.

During all "times ten" (x 10) operations the start-stop pulse frequency is divided by 10 so that the counting period is multiplied by 10 and the reading is 10 times as large. Figures 4a thru f show the selection of pulse sources for each operation.

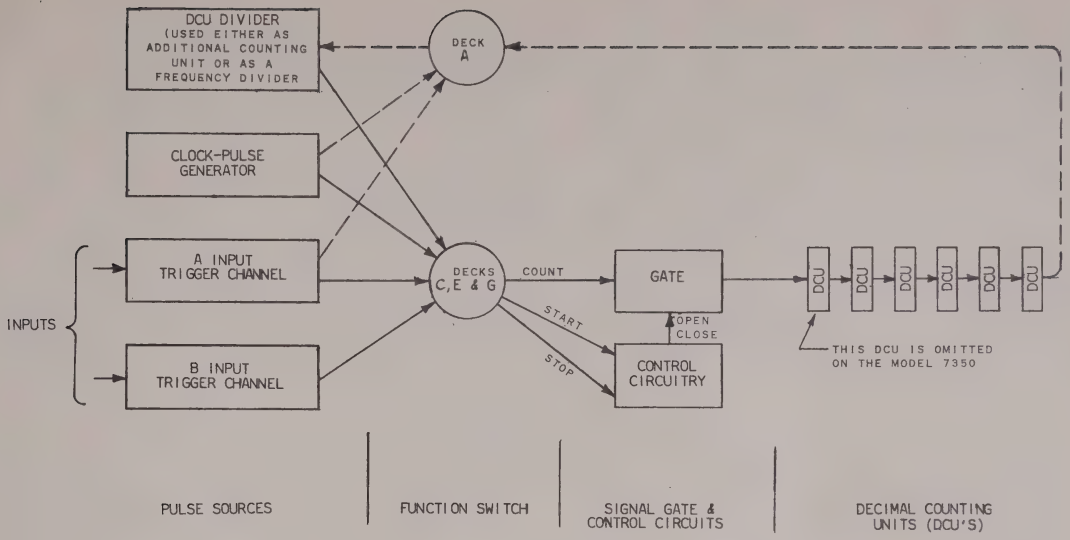


Figure 2 Signal Paths between Major Components

OPERATING CONTROL & CONNECTOR FUNCTIONS

CONTROLS

POWER switch

Turns power on and off.

FUNCTION switch

1. Interconnects major components to perform the measurement indicated by the pointer.
2. Used to manually control COUNT and SCAN operations.

TIME-SECONDS switch

Selects time interval for events-per-unit-time & TEST measurements and unit of time measurement for PERIOD and TIM measurements.

ATTENUATION controls

Attenuates the signal at the adjacent INPUT jack by the voltage factor to which the pointer is set. When turned to the AC side only the a-c component of the input signal reaches the input trigger channel.

TRIGGER VOLTAGE Controls

Selects the instantaneous voltage at which the attenuated signal triggers the adjacent input channel.

SLOPE switches

Selects the slope of the input voltage waveform which triggers the input channel pulse used to operate the gate and control circuitry. The input channel which each SLOPE Switch affects varies with the position of the FUNCTION switch. See "PERFORMING SPECIFIC OPERATIONS" to determine the function of the SLOPE switches at a particular position of the FUNCTION switch.

DISPLAY Time Control

Determines how long the instrument holds a reading before resetting and beginning another count. When this control is turned to the extreme clockwise position, the instrument will hold a reading until the manual RESET button is depressed.

Manual RESET Button

Removes the previous reading and readies the instrument to begin another counting period.

INPUT Trigger Channel Jacks

Inputs to the two Input Trigger Channels

FREQUENCY Jack (Chassis Rear)

When the EXT-INT switch is at INTernal, the 1 MC oscillator signal is available here. When the switch is at EXTernal, the external reference frequency must be connected to this jack.

COUNTER INPUT ADJUSTMENTS

INPUT ADJUSTMENTS WHEN COUNTING CYCLES OF A SINE-WAVE SIGNAL

In the common case in which the input approximates a sine-wave signal having a frequency between 10 cps and 2.1 MC, and when the object is merely to generate one pulse for each cycle without regard for the precise time at which a pulse occurs, the ATTENUATION and TRIGGER VOLTAGE controls may be set as follows:

1. Couple the input signal to the B INPUT jack. Input sensitivity is 100 mv rms (0.3 volts peak-to-peak). Input impedance is 10 megohms.
2. Place FUNCTION switch at COUNT and press manual reset button. (SLOPE switches may be in any position.)
3. Rotate the TRIGGER VOLTAGE control slowly from one extreme to the other while the ATTENUATION control is at each of the three positions on the AC side (1, 10 & 100). Notice that the instrument will count steadily over a certain arc of TRIGGER VOLTAGE positions for each ATTENUATION setting. Choose the highest ATTENUATION position at which counting will continue over an arc of at least 45 degrees rotation of the TRIGGER VOLTAGE control.
4. Position the TRIGGER VOLTAGE control at the center of the arc over which counting occurs.

EFFECT OF INPUT CONTROLS

Figure 3a is a block diagram of an input trigger channel.

The impedance at the INPUT jack is 10 megohms in parallel with 35 micromicrofarads. This impedance may be reduced to match the source or to avoid capacitive pickup by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. The input sensitivity is equal to 0.3 volts peak-to-peak times the factor to which the ATTENUATION control is set. The input circuitry will withstand a signal as strong as 500 volts peak-to-ground without damage.

The attenuator divides the voltage introduced at the INPUT jack by the factor indicated by the ATTENUATION control. When the control points to a factor on the side labelled "DC", the total INPUT signal is attenuated and passed on. When the control points to a factor on the side labelled "AC", the d-c component is removed and only the a-c component is attenuated and passed on. Frequencies as low as 1 cps will be passed in the "AC" positions.

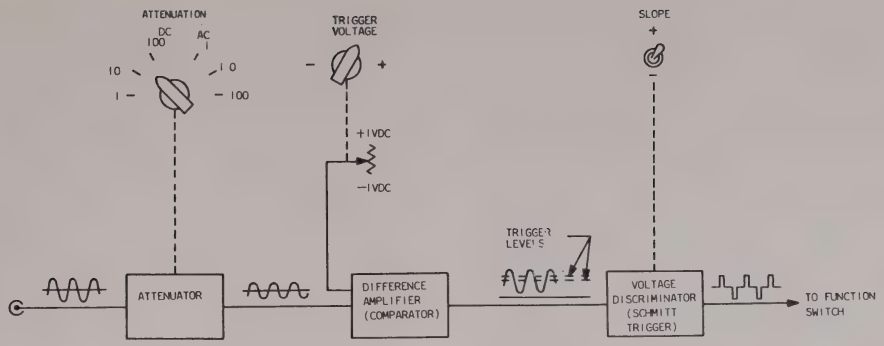


Figure 3a

Figure 3b shows how the varying voltage of the attenuated signal triggers channel output pulses. A pulse is produced each time the instantaneous voltage of the attenuated signal passes through the "positive-going trigger voltage" starting from a value more negative than the "negative-going trigger voltage". Another pulse is produced each time the instantaneous attenuated voltage passes through the "negative-going trigger voltage" starting from a value more positive than the "positive-going trigger voltage". When the SLOPE switch is at "+", only pulses triggered by positive-going voltage excursions affect the succeeding circuitry. With the SLOPE switch at "-", only pulses triggered by negative-going excursions are effective.

The two trigger voltage levels (positive-going and negative-going) are always separated by 0.3 volts, the effective hysterisis. Because a voltage excursion must travel through both levels to trigger a pulse, the sensitivity of the channel to the attenuated signal is 0.3 volts peak-to-peak.

The trigger voltage levels of either input channel may be raised or lowered simultaneously (maintaining 0.3-volt separation) when the TRIGGER VOLTAGE control for that channel is varied. This control will vary the levels from roughly -1 volt to +1 volt. Referring to figure 3, notice that the TRIGGER VOLTAGE control actually raises or lowers the d-c level of the input to the voltage discriminator. However, this action has the effect of raising or lowering the trigger voltage levels at the input to the difference amplifier.

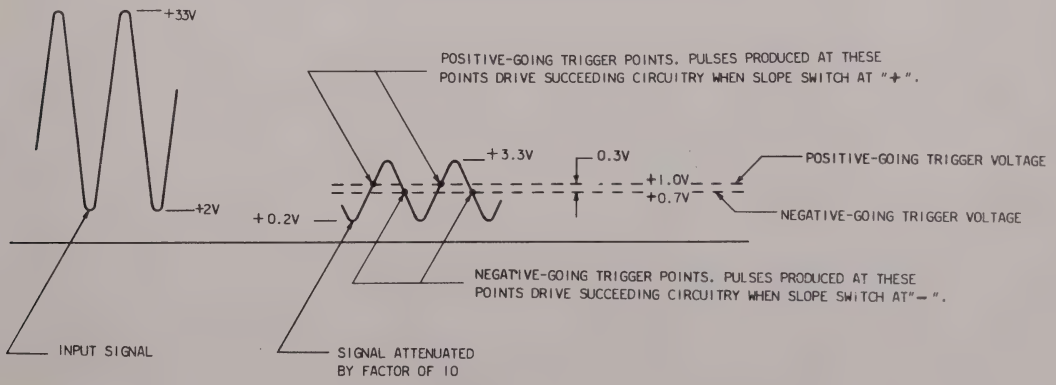

+33V
+2V
+0.2V
POSITIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT "+".
+3.3V
0.3V
+1.0V
+0.7V
POSITIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT "−".
INPUT SIGNAL
SIGNAL ATTENUATED BY FACTOR OF 10

Figure 3b

The purpose of the input trigger channel is to produce a reliable pulse output representing that part of the input signal in which the operator is interested. This is achieved only when the ATTENUATION and TRIGGER VOLTAGE controls are properly adjusted. Before attempting to adjust the controls, it is best to visualize the input waveform, noting the shape, a-c amplitude and d-c level. The effect of various control settings is then relatively easy to calculate. Referring to figure 3, notice that:

1. If the attenuated signal is small peak-to-peak, the trigger voltage levels may be set so high or so low that no pulses are produced. In figure 3, for example, if the "positive-going trigger voltage" were set at -0.5 volts (thus placing the "negative-going trigger voltage" at -0.8 volts), the attenuated signal with peaks at +0.2 and +3.3 volts would not intersect either trigger voltage level.
2. If the attenuated voltage variations ride on a d-c level, they may not come within the trigger voltage range. In figure 3, again, if the input signal were not attenuated (or a-c coupled) the negative peak at +2 volts would not intersect any possible trigger voltage level.
3. Modulation or variations in the d-c level of the attenuated signal are least likely to subtract pulses if the trigger voltages are set about halfway between the peaks of the signal.
4. Extraneous signals (noise, hum, modulation, drift, etc.) have the least effect on the time at which a pulse occurs when the channel triggers on a steep slope of the waveform.
5. Noise below 0.3 volts peak-to-peak will not trigger extraneous pulses. Consequently, attenuating a signal carrying a given percentage of noise may eliminate the effect of the noise. For example, 1 volt peak-to-peak noise on a 6 volt peak-to-peak signal will trigger extraneous pulses. If the signal is attenuated by a factor of 10, the resulting 0.6 volt p-p signal will still trigger desired pulses dependably, while the resulting 0.1 volt p-p noise is well below the sensitivity of the channel.
6. Attenuating the input signal
   (a) Reduces the slope at all points
   (b) Shifts the a-c component nearer ground if it rides on a d-c level.
   (c) Increases the minimum peak-to-peak variations necessary to trigger pulses (measured at the INPUT jack) from 0.3 volts to 3 or 30 volts
   (d) Increases the range of possible trigger voltage setting on the input signal from ±1 volt to ± 10 volts or ± 100 volts.

Adjustment of ATTENUATION and TRIGGER VOLTAGE controls should be made keeping the above characteristics in mind. When using any regular periodic input signal, consistent E/UT or PERIOD readings are a good indication that the controls are properly adjusted.

The point on an input waveform where the input channel triggers may be seen on an oscilloscope. Observe the input of the voltage discriminator in the input channel used (V303, Pin 2). The waveform which appears is the amplified input signal together with small "notches" created on each slope as the channel triggers. Rotating the TRIGGER VOLTAGE control will cause these notches to move up and down the waveform. See "Typical Waveforms" for a sample display.

The trigger voltage may be set at a precise value by applying a d-c voltage of that value at the INPUT jack, setting the ATTENUATION control at an appropriate factor on the DC side and rotating the TRIGGER VOLTAGE control to the point where an output pulse is produced. With no input voltage the INPUT jack lies at ground and a pulse will be produced at ground level. Output pulses from the B channel may be seen being counted when the FUNCTION switch is at E/UT. Pulses from the A channel are counted on the A/B position.

Some information about the position of the trigger voltage relative to the signal may be extracted from the instrument itself. The trigger voltage may be varied between the positive and negative peaks of an attenuated signal whose peaks lie within the range -1 to +1 volts. As the trigger voltage pass beyond the signal peaks the pulse output of the channel will cease and these positions of the control may be noted.

PERFORMING SPECIFIC OPERATIONS

MEASURING FREQUENCY

The frequency of a regular sine-wave signal can be measured either directly under E/UT or E/UT x 10 Operation or indirectly by measuring the period of the signal and calculating the frequency. The direct method is simpler and will ordinarily be used except when measuring a low frequency signal with extreme accuracy. See the "ACCURACY" section of this manual for the accuracy limitations of events-per-unit-time operation.

NOTE: At "X10" positions of the function switch, the DCU at the far left does not function in the counting chain; therefore, disregard its indication.

TEST Operation

To put the instrument in operation connect the power cord and place the POWER switch in the position which lights the green indicator above it. After a two minute warm-up, test the instrument for proper operation:

1. Turn DISPLAY Time to a point near the extreme counter -clockwise position to obtain a short display time and automatic operation.
2. Turn FUNCTION switch to TEST.
3. Rotate TIME switch to each position starting with the 10-5 seconds setting on the Model 7360 or the 10^{-4} seconds setting on the Model 7350. In either case this should give a reading of 10. As the switch is turned clockwise, other settings should read successively 100, 1000 or 999, 10, 000 or 9, 999, 100, 000 or 99, 999 and (on the Model 7360 only) 1, 000, 000 or 999, 999.

Note that the DISPLAY time is infinite at the extreme clockwise position of the control. In this position, the instrument must be reset manually.

E/UT (Events-Per-Unit-Time) Operation

At the E/UT position of the FUNCTION switch the unit counts the input to the B Channel between start and stop signals separated by a precise time interval. This setting may be used to measure the frequency of a signal or the number of events occuring within a selected time interval. The major components are connected as diagramed in Figure 4a.

To make a measurement proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to the E/UT position. In this position the SLOPE

switch on the B-START-E/UT-PERIOD side of panel determines the polarity of the voltage excursion which triggers count pulses. It may be at either position.

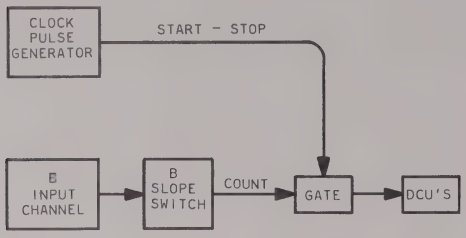


Figure 4a

3. Set the TIME switch at the time interval over which events are to be counted.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in events per second, divide the reading on the lighted DCU's by the number to which the TIME switch is set.

E/UT x 10 Operation

At the E/UT x 10 position of the FUNCTION switch the unit counts every cycle of the input to the B channel between stop and start signals separated by 10 times the interval indicated by the TIME switch. This setting may be used to obtain a 10-second time interval. Counting over the 10-second period produces more accurate frequency measurements than may be made using shorter time intervals. The major components are connected as diagramed in Figure 4a except that the output of the Clock-Pulse Generator is fed through the DCU Divider before reaching the Gate. To make a measurement proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate FUNCTION switch to the E/UT x 10 position.
3. Set the TIME switch. At this position of the FUNCTION switch the interval during which events are counted is 10 times that indicated by the TIME switch.
4. Adjust the DISPLAY TIME control for a convenient reading.
5. To obtain a reading in events per second divide the reading on the DCU's by 10 times the factor indicated by the TIME switch.

SCAN Operation

The interval during which events are counted may be extended to any multiple of the 1 or 10-second counting periods. Consider the total counting interval desired as N counting periods. Then proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn DISPLAY TIME control fully clockwise.
3. Place FUNCTION switch at E/UT or E/UT x 10.
4. Select a one or ten-second counting period. If the FUNCTION switch is at E/UT x 10 turn the TIME switch to 1 to obtain a 10-second period and to 10^{-1} to obtain a one-second period.
5. Press the RESET button. Within 1 second the instrument will begin a normal counting period.
6. Before the end of this period (one or 10 seconds as the case may be) turn the FUNCTION switch to the SCAN position and begin timing N minus 1 counting periods with a stopwatch.
7. At the end of N minus 1 periods turn the FUNCTION switch back to E/UT or E/UT X 10.
8. When the instrument stops counting, read the count. Ignore the digit (if any) appearing on the DCU farthest to the left. This DCU has not been counting continuously during the extended interval.

A/B Operation

At the A/B position of the FUNCTION switch the unit counts the signal at the A INPUT between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the ratio of two frequencies or to count the number of events occurring while the B INPUT is above or below a given voltage level. The major components are connected as diagramed in Figure 4b.

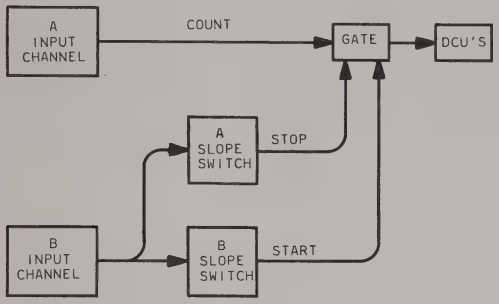


Figure 4b

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to A/B. In this position the SLOPE switch on the B side of the panel determines the polarity of the voltage excursion which begins count of the A input. The other SLOPE switch sets the polarity of that which ends the counting period.
3. Therefore,
   (a) When measuring the ratio of two frequencies set both SLOPE switches "+" or both to "-".
   (b) When counting the A input during the period the B input voltage remains above a certain level, set the SLOPE switch on the B side to "+" and the other to "-".
   (c) When counting the A input during the period the B input voltage remains below a certain level, set the SLOPE switch on the B side to "-" and the other to "+".
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.
5. Take a reading. When measuring a frequency ratio the DCU's indicate the ratio of the A input frequency to the B input frequency.

A/B x 10 Operation

At the A/B x 10 position of the FUNCTION switch the unit counts the signal at the A INPUT between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure a frequency ratio more accurately than the A/B operation. The major components are connected as diagramed in Figure 4c.

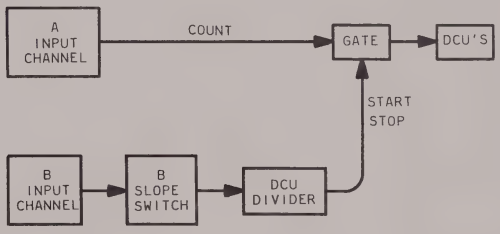


Figure 4c

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENT" above).
2. Rotate the FUNCTION switch to A/B x 10. In this position the B SLOPE switch determines the polarity of the voltage excursion which begins and ends counting.
3. For greatest accuracy set this SLOPE switch on the steeper slope of the B input
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.

5. Divide the reading by 10 to obtain the ratio of the A INPUT frequency to the B INPUT frequency.

TIM (Time-Interval-Meter) Operation

At TIM position of the FUNCTION switch the unit measures the time between a voltage excursion through a selected level at the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT. The major components are connected as diagramed in Figure 4d.

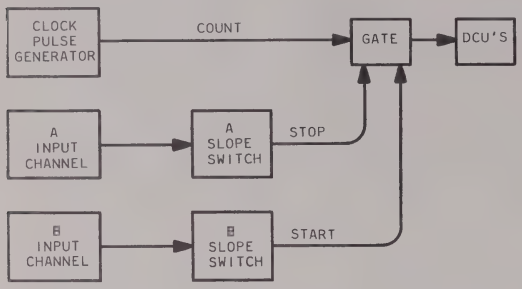


Figure 4d

To make a measurement proceed as follows:

1. Connect the start signal to the START INPUT and the stop signal to the STOP INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to TIM. In this position the B SLOPE selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Rotate the TIME switch to the desired unit of time measurement. For example, at the 10^{-4} position the time measurement appears in ten-thousandths of a second. The smaller the time unit chosen, the more accurate the reading.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in seconds, multiply the count on the DCU's by the factor to which the TIME switch is set.

PERIOD Operation

At the PER position of the FUNCTION switch the unit measures the time interval between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the period of a wave or the width of a pulse. The major components are connected as in Figure 4e.

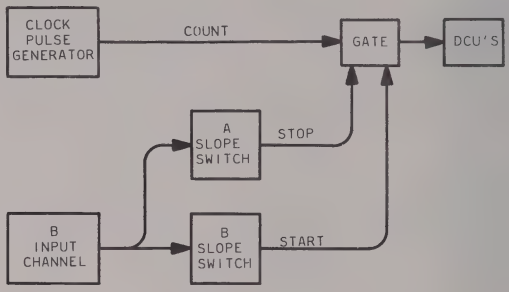


Figure 4e

To make a measurement proceed as follows:

1. Connect the wave or pulse source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PERIOD. At this position the B SLOPE switch selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Therefore,
   (a) When measuring the period of a wave, set both SLOPE switches to "+" or both to "-".
   (b) When measuring the width of a positive pulse, set the B SLOPE switch to "+" and the A SLOPE switch to "-".
   (c) When measuring a negative pulse, set the B SLOPE switch to "-" and the A SLOPE switch to "+",
4. Follow steps 3, 4 & 5 under "TIM Operation".

PERIOD x 10 Operation

The unit measures the time interval between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure the period of a wave more accurately than the PERIOD operation. The major components are connected as diagramed in Figure 4f.

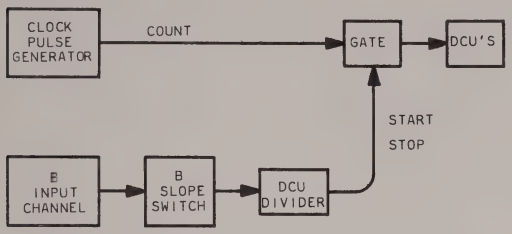


Figure 4f

To make a measurement proceed as follows:

1. Connect the wave source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PFRIOD x 10. The B SLOPE switch selects the polarity of both start and stop voltage excursions.
3., 4 & 5. Follow steps 3, 4 & 5 under "TIM Operation".
6. Divide the reading by 10 to obtain the length of one period.

COUNT Operation

The unit counts the input to the B channel during the period the FUNCTION switch is in the COUNT Position.

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn FUNCTION switch to OFF.
3. Depress manual RESET button.
4. Twist FUNCTION switch to COUNT to begin counting.
5. Twist FUNCTION switch to OFF to stop counting.

GATE Operation

This operation is a variation of TIM operation. Pulses generated by an external signal are substituted for internal clock pulses. The instrument counts cycles of the substituted signal between a voltage excursion through a selected level as the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT.

The substituted signal must have an amplitude of 3 volts rms into a 7K load. Its frequency may be as high as 100KC in the case of the Model 7350 or as high as 1MC in the case of the Model 7360. Couple the signal to the FREQ. jack at the rear of the counter and place the EXT-INT switch at EXT.

NOTE: The .01 μf capacitor (C401) connected between the FREQ. jack and the input circuit used for this operation is not large enough to pass frequencies lower than 10KC. If the external signal frequency is lower than 10KC, jumper this capacitor and connect a larger capacitor between the signal source and the FREQ. jack.

Rotate the TIME switch to 10^{-5} on the Model 7350 or to 10^{-6} on the Model 7360. Place the FUNCTION switch at TIM. Adjust the START and STOP input channels as described under "INPUT ADJUSTMENTS". See "TIM Operation" to learn how the SLOPE switches operate on these channels. The shaper stage of the clock pulse generator is used as the input trigger channel for the signal introduced at the FREQ. jack. Adjust the input trigger voltage of this channel with the SHAPER LEVEL control located on the top side of the counter chassis. Rotate this control to find the limits of the range in which the instruments counts. Set the control at the center of this range.

USING AN EXTERNAL REFERENCE FREQUENCY

An external reference frequency may be substituted for the internal oscillator signal. Introduce the external signal as described under "GATE Operation," but place the TIME switch at a position which produces a clock pulse frequency equal to the reference frequency divided by the desired power of 10.

REMOTE CONTROL OF OPERATING CYCLE

The counter can be controlled from a remote location so that it will not reset and begin another count until desired. Set the DISPLAY time control at a minimum and string a lead from the remote location to Pin 40 of the DIGITAL RECORDER socket. As long as this lead is grounded the counter will not reset. If a count is complete, then within 40 milliseconds after the lead is ungrounded the counter will have reset and be ready to start counting when a start pulse appears. As soon as the counter has reset, the lead may be grounded again or left ungrounded. It will not affect the operating cycle until the time arrives for the next automatic reset. At that time it must be grounded again to prevent reset.

ACCURACY

Measurements are subject to four important sources of error.

1. Counts missed or added as the Gate opens and closes.
2. Clock signal inaccuracy.
3. Errors in the time a start or stop pulse is triggered.
4. Counts missed because they occur during the resolution time of the counting circuits.

1.

Pulses which occur simultaneously with the opening or closing of the Gate may or may not be counted. This causes all measurements to vary plus or minus one count. The following equation defines the possible error introduced.

$$(1)\ \text{Max. \% error} = \frac{1}{\text{Count Indication}} \times 100.$$

Notice that measurements set up to yield the highest count indication will be most accurate.

The frequency of a sine wave signal can be measured directly by counting events-per-unit-time or indirectly by measuring the length of one period and calculating the frequency. Higher frequencies yield the highest count indication when measured directly, that is, using the E/UT or E/UT x 10 function. Lower frequencies produce the highest indication when rapid time signals are counted over one or ten periods - that is, using the PERIOD or PERIOD x 10 function.

On the Model 7360 frequencies above 1KC produce the highest count indication when measured using the E/UT x 10 function and a 10-second time interval; frequencies below 1KC yield the highest count when measured with the PERIOD x 10 function and a 1 μsecond unit of time measurement. The accuracy achieved using alternative functions at various frequencies is graphically illustrated in Figure 6. Note that the curves for E/PUT x 10 (10-second interval) and PERIOD x 10 (1 μsec time unit) cross at 1KC. This frequency cannot be measured with a possible error less than .01%. Frequencies above and below may be measured with greater accuracy.

The smallest unit of time available on the Model 7350 is 10 μseconds. Lower frequencies are most accurately measured using the PERIOD X 10 function and this time unit. Notice on Figure 5 that this curve crosses the EPUT X 10 curve at 316 cps. Therefore on the Model 7350 frequencies above 316 cps are most accurately measured using EPUT x 10 and a 10-second time interval whereas frequencies below 316 cps are best measured using the PERIOD x 10 function and the 10 μsecond unit of time. 316 cps cannot be measured with a possible error less the .03%,

but lower and higher frequencies may be measured more accurately.

2. All measurements requiring a time signal (i.e. all measurements except A/B, A/B x 10 and COUNT) are subject to an additional error introduced by variations in the oscillator frequency. The oscillator frequency in the Model 7360 is stable to 2 parts in 10^7 per week, so it can cause a maximum error of only .00002%. The oscillator in the Model 7350 is stable to 1 part in 10^6 per day. It causes a maximum error of .0001%.

3. Measurements using a external signal to trigger start and stop pulses (i.e. PERIOD, PERIOD x 10, TIM, A/B and A/B x 10) may be subject to a further error caused by pulses which are triggered too soon or too late. Refer to Figure 5 which illustrates what occurs during a simple period measurement.

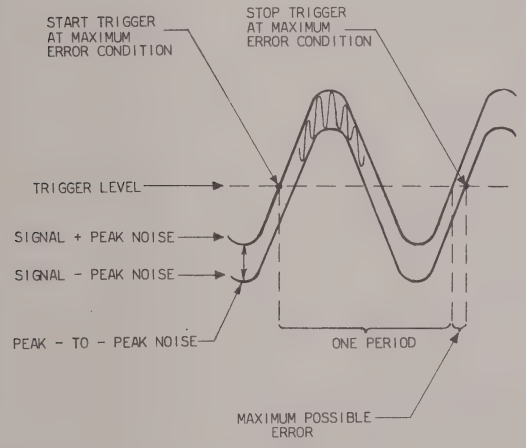

START TRIGGER AT MAXIMUM ERROR CONDITION
STOP TRIGGER AT MAXIMUM ERROR CONDITION
TRIGGER LEVEL
SIGNAL + PEAK NOISE
SIGNAL - PEAK NOISE
PEAK - TO - PEAK NOISE
ONE PERIOD
MAXIMUM POSSIBLE ERROR

Figure 5 Effect of Noise on Accuracy of Period Measurements

Consider the total signal as an ideal signal intended to trigger the input channel plus a noise signal. The noise voltages added or subtracted from the ideal signal may trigger a pulse before or after the instant at which counting should begin or end. The maximum error in the time of triggering will be proportional to the noise amplitude and inversely proportional to the slope of the ideal signal at the trigger level. Expressed mathematically,

$$(2)\quad t\ (\text{secs}) = \frac{V_n\ (\text{volts})}{S\ (\text{volts/sec})}$$

where t = Max. error in trigger time

V_n = peak-to-peak noise

S = slope of ideal signal at trigger level

The total noise (V_n) is equal to that carried by the input signal after attenuation plus that internally generated by the input channel. The internal noise (which takes the form of amplifier drift, trigger level jitter, line frequency pick-up, etc) is not more than 300 microvolts. Note that as the amplitude of of the input signal is increased, S in equation (2) becomes larger and the internal noise causes less error.

The percentage error may be calculated by dividing the error in trigger time by the counting period and multiplying by 100. In the common case of a period measurement of a sine wave triggering at its zero crossover value:

$$(3)\quad \text{Max. \% error} = \frac{V_n\ (\text{volts})}{V_s\ (\text{volts}) \times \pi} \times 100$$

where V_n = peak-to-peak noise

V_s = peak-to-peak signal

The maximum percent error of a PERIOD x 10 measurement is one-tenth the value given in equation (3).

The total error due to the three causes mentioned above is equal to the sum of the separate errors.

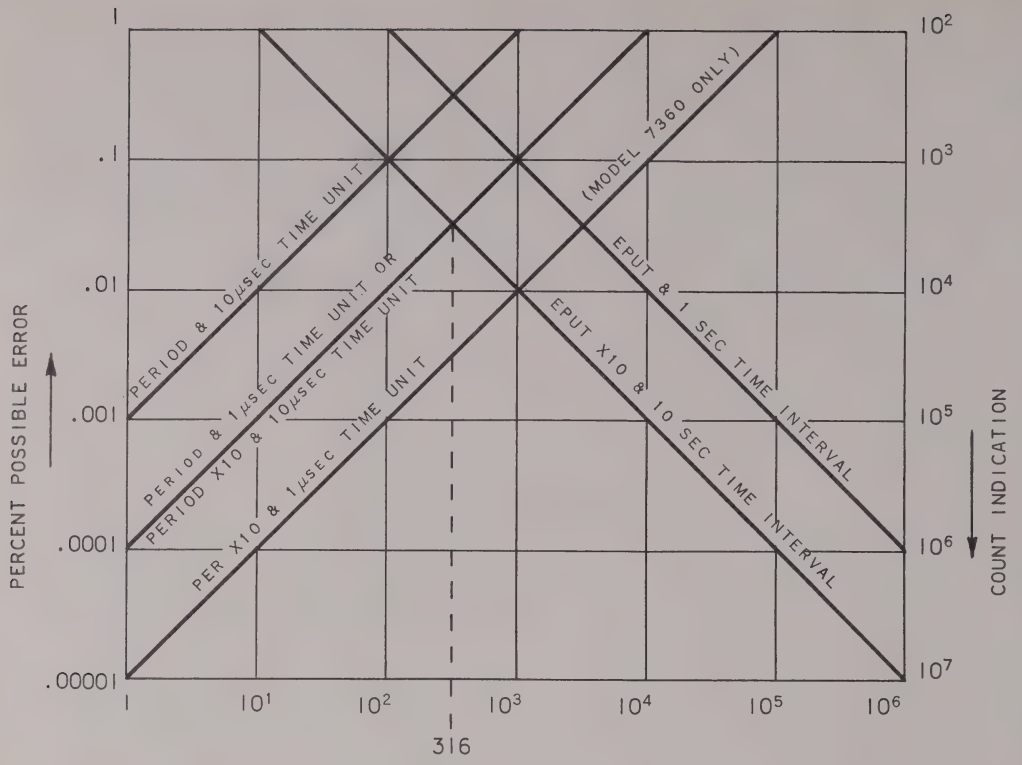
Total Max. percent error equals:

$$\frac{100}{\text{Count}} + \begin{matrix}.00002\ (7360) \\ \text{or} \\ .0001\ (7350)\end{matrix} + \text{Percent error due to noise}$$

$\frac{100}{\text{Count}}$ ↓ If E/UT, E/UT x 10, PERIOD, PERIOD x 10

.00002 (7360) or .0001 (7350) ↓ If E/UT, E/UT x 10, PERIOD, PERIOD x 10

Percent error due to noise ↓ If PERIOD, PERIOD x 10, TIM, A/B or A/B x 10



NOTE: THE 1 μSECOND TIME UNIT IS NOT AVAILABLE ON THE MODEL 7350

Figure 6 Error due to ± 1 Count Limitation

4. Another source of error becomes important when random events are counted. One such event may occur immediately after another, before the counting circuits are fully recovered and prepared to register it. The second event will not only fail to cause a count but its effect on the circuitry may cause a third event to fail to register also. Formulae for calculating the counting error due to this effect may be found in "Application of Probability Theory to Nuclear Particle Detection", L. J. Rainwater and C. S. Wu, Nucleonics, October 1947. The minimum time which must elapse between events if both are to be counted is called resolution time of the instrument. The Model 7360 has a resolution time of .8 μseconds. The Model 7350 has a resolution time of 5 μseconds.

AUXILIARY CONNECTORS

DIGITAL RECORDER Jack. Each DCU generates a 4-line code representing the digit it is displaying. These lines are collected at the DIGITAL RECORDER socket at the rear of the instrument. The Model 1452 Digital Recorder plugs directly into this socket. The socket also makes mutual control connections between the counter and the recording device.

In the four-line code "0" represents a voltage 15 or more volts negative of ground; "1" represents a voltage at ground or positive of ground.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1
No Digit	0	0	1	0

	PIN NO. ON DIGITAL RECORDER SOCKET			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
Highest order digit read*	Pin 4	Pin 3	Pin 2	Pin 1
2nd highest order digit	8	7	6	5
3rd highest order digit	12	11	10	9
4th highest order digit	16	15	14	13
5th highest order digit	20	19	18	17
6th highest order digit**	24	23	22	21

* On instruments featuring "times ten" positions of the FUNCTION switch no read-out pins are provided for the left-most DCU, which displays the highest order digit during some measurements. On these instruments the highest order digit represented by a 4-line code is in the front-panel column second from left.

** On instruments containing only five read-out DCU's pins 21 thru 24 are permanently wired to produce the "no digit" code which is "0010".

Pin 39 carries a control signal from the counter. This pin is negative during the display period and positive from reset until the end of the next counting period.

Pin 40 is the "inhibit reset" line. When this pin is grounded the counter cannot reset.

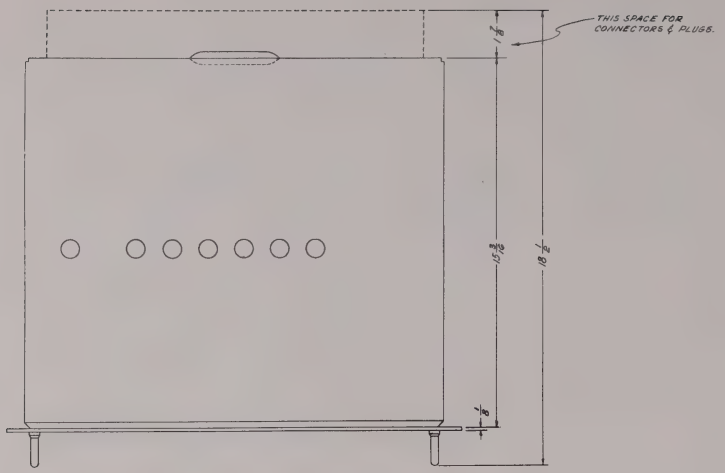
Pin 38 is grounded. Pins 25 thru 37 are not connected to anything.

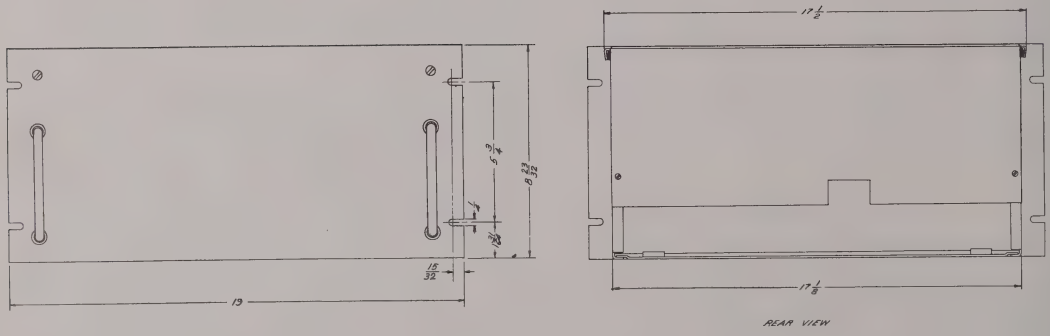
TIME Jack. The output signal of the clock-pulse generator is available at this jack. The signal consists of positive pulses 2.5 volts in amplitude. The positive transients are accurately spaced at the interval indicated by TIME switch. These transients are recommended for external use as a clock signal. The negative transients occur at the same frequency but are not so accurately spaced. The output impedance is 330 ohms.

FREQ Jack. A sine-wave signal at the oscillator frequency is available at this jack when the EXT-INT switch is at INT. The signal is 10 volts peak-to-peak out of 3000 ohms. When the EXT-INT switch is at EXT., an external signal can be introduced at this jack to substitute for the oscillator signal as described under "GATE Operation".

SCOPE Jack. This jack is connected thru 220K to the suppressor grid of the gate tube. The voltage on the grid determines whether the gate is "open" or "closed". The voltage at the jack is about ground level when the gate is open and about -22 volts with respect to ground when the gate is closed. If the waveform of a signal generating start-stop pulses is displayed on an oscilloscope, the signal at the SCOPE jack may be used to blank the scope during the period the gate is closed. The scope will then display the portion of the wave form whose length is being measured.

ACCESSORY Jack. This socket provides connections to +120 VDC regulated at 10 ma, -110 VDC at 15 ma, +190 VDC at 20 ma and 6.3 VAC at 2 amperes. These supplies may be used to power auxiliary equipment such as transducers. The power supply schematic shows at which terminal each supply is available.





CHASSIS MOUNTING DIMENSIONS, MODELS 7150, 7160, 7250, 7260, 7350, 7360

3 Circuit description

NOTE: It is intended that the reader refer frequently to relevant schematic diagrams while reading the material in this section. The Decimal Counting Units are described in an appendix.

GATE & CONTROL CIRCUITRY

The Gate and control Circuitry receive three pulse inputs from the FUNCTION switch (S201): pulses to be counted, start pulses and stop pulses. Pulses to be counted go from Deck G to the signal grid of the Gate tube (V204). The plate of this tube is coupled to the first of the cascaded DCU's. During the period its suppressor grid is at ground the tube amplifies the grid signal and drives the DCU's. In this state the Gate is "open". When the suppressor grid is below -10 volts, the tube is cut off and the Gate may be considered "closed".

The "open-close" voltages on the Gate tube suppressor grid are generated at the right plate of the Control Binary (V203). V203 is a conventional "flip-flop" circuit. Such a circuit has two stable states: left half conducting, right half cut off; and right half conducting, left half cut off. Input pulses or transients applied at various points on the circuit will trigger it back and forth between the two states. When the right half of V203 is conducting, the right plate is 30 volts negative. A negative start transient from the Start Binary, applied at the left plate of V203 and coupled through C210 to the right grid, triggers V203 to its other stable state. In this state the right half is cut off and the right plate rises above ground permitting the Gate tube to conduct.

When a negative stop pulse from Deck E of the FUNCTION switch reaches the left grid of V203 through the diode V201B, V203 is triggered back to the state which holds the Gate closed.

The Start Binary is also a "flip-flop" circuit. It produces a negative start transient at its right plate each time that half begins to conduct. Its left grid is coupled to Deck C of the FUNCTION switch through the diode V201A and C201. When the left half is conducting a negative start pulse at the grid triggers a change to the other stable state producing the output transient. Further negative pulses at the left grid have no effect since that half is already cut off.

When the instrument is ready to begin a counting period the right half of the Control Binary and the left half of the Start Binary are conducting and the Gate is closed. Negative stop pulses received at the left grid of the Control Binary have no effect since this half is cut off. The following sequence occurs. (Refer to Figures 7 & 8).

Time (1) A start pulse passes through the injection diode V201A and triggers the Start Binary which in turn triggers the Control Binary to a state which opens the Gate. The DCU's then

count and indicate the number of pulses reaching the Gate.

Time (2) A stop pulse triggers the Control Binary to a state which closes the Gate.

At this point, if the instrument is set to operate automatically, the reset circuitry begins to function. The reset control voltage appears at the junction of CR201 and CR203. Its value is determined by the combined effect of the voltage on the right plate of the Start Binary and that on the right plate of the Gate Control Binary. At the close of a counting period (and only then) both these plates are negative. The resulting negative voltage at the junction is applied to the input grid of the Reset Generator through R239.

The Reset Generator (V205) is a two stage amplifier. The first stage (the left half) is a voltage amplifier. The second stage is a cathode follower. The Reset Generator performs two functions. It amplifies the reset control voltage at time (2) and it produces a reset pulse upon receiving a signal from the Reset Control at time (3). The negative reset control voltage is amplified, inverted and coupled from the output cathode to the DISPLAY time potentiometer (R247) through R244, CR206 and S204. The positive charge at R247 leaks onto C216. C216 is coupled to the input grid of the Reset Control (V206) through S205B. When this grid rises above a certain voltage, V206 generates an output pulse which initiates step (3), the reset action.

The Reset Control is a monostable multivibrator. In its stable state the right triode is conducting and the left triode is cut off. When the left grid becomes sufficiently positive, that half begins to conduct and right side is cut off momentarily by a negative pulse produced at the left plate and coupled to right grid by C218. The output is a positive pulse at the right plate.

This positive pulse is coupled through R236 and R239 to the input grid of the Reset Generator producing a negative transient at the plate of the first stage which resets all the DCU's and Start Binary. The positive pulse from the Reset Control is also coupled to the cathode of the Start Binary injection diode by R212, C203 and R209. The positive charge on the cathode prevents negative start pulses from reaching the Start Binary until all reset transients have decayed. At time (4), about 15 milliseconds after the reset pulse, the control circuitry is ready to accept another start pulse.

NOTE: When the counter is equipped with the Model 1452 Digital Recorder, the sequence of operations described above is interrupted briefly. A relay in the recorder grounds the input to the DISPLAY time potentiometer from the end of the counting period (time (2)) until the recorder has collected count information from the DCU's. (See Figure 9). The connection to the recorder is made through pin 40 of J202.

When the DISPLAY time control is turned fully clockwise the input connection to this potentiometer is broken by S204 and the automatic reset action will not occur. The DCU's hold the accumulated count until the manual RESET button is depressed. Depressing this button actuates S205A and S205B. S205A connects the -110 volt supply to the Reset Generator input grid. S205B connects C216 to the output cathode of the Reset Generator which is then at a high positive voltage. When the button is released the positive charge on C216 flows onto the Reset Control grid and initiates the same reset action that occurs under automatic operation.

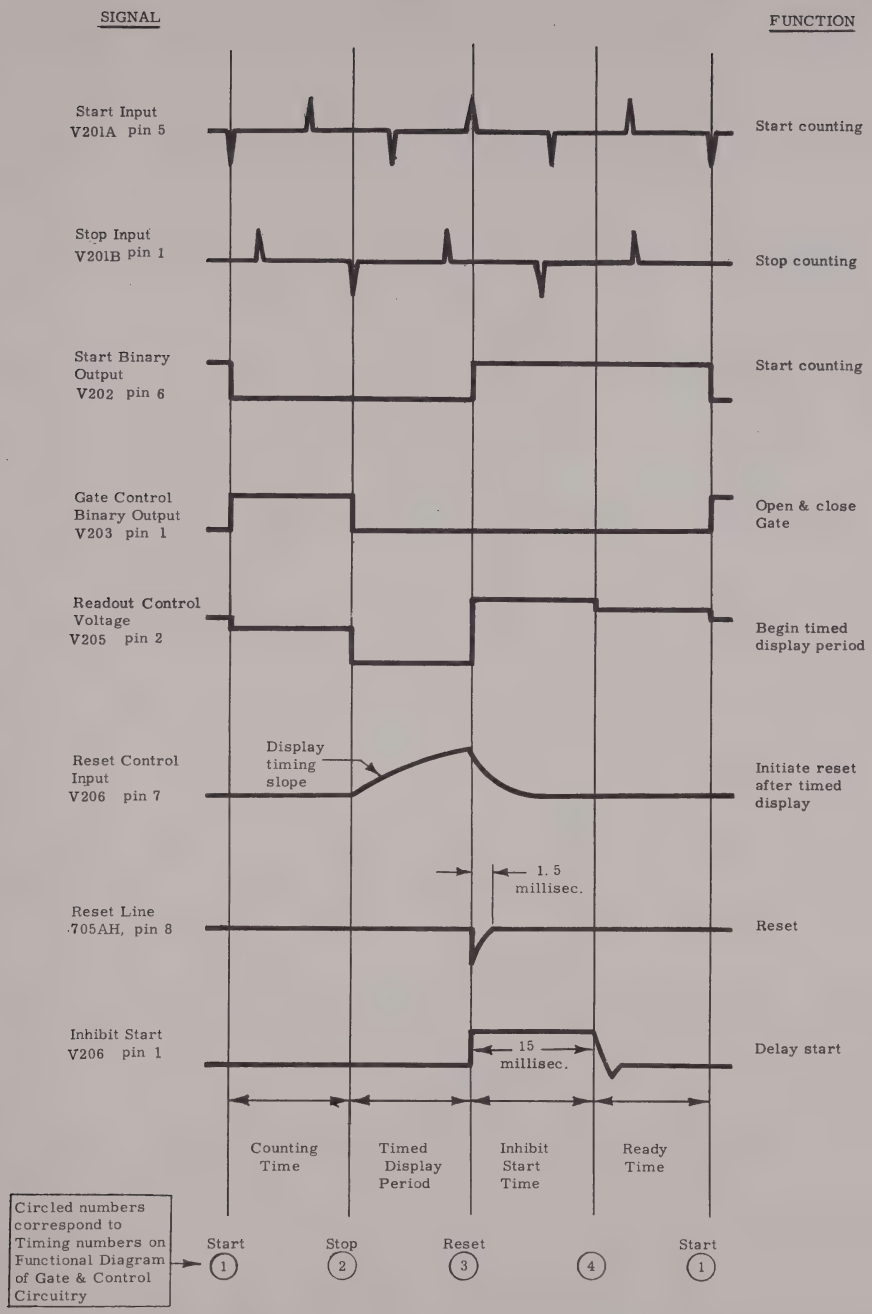
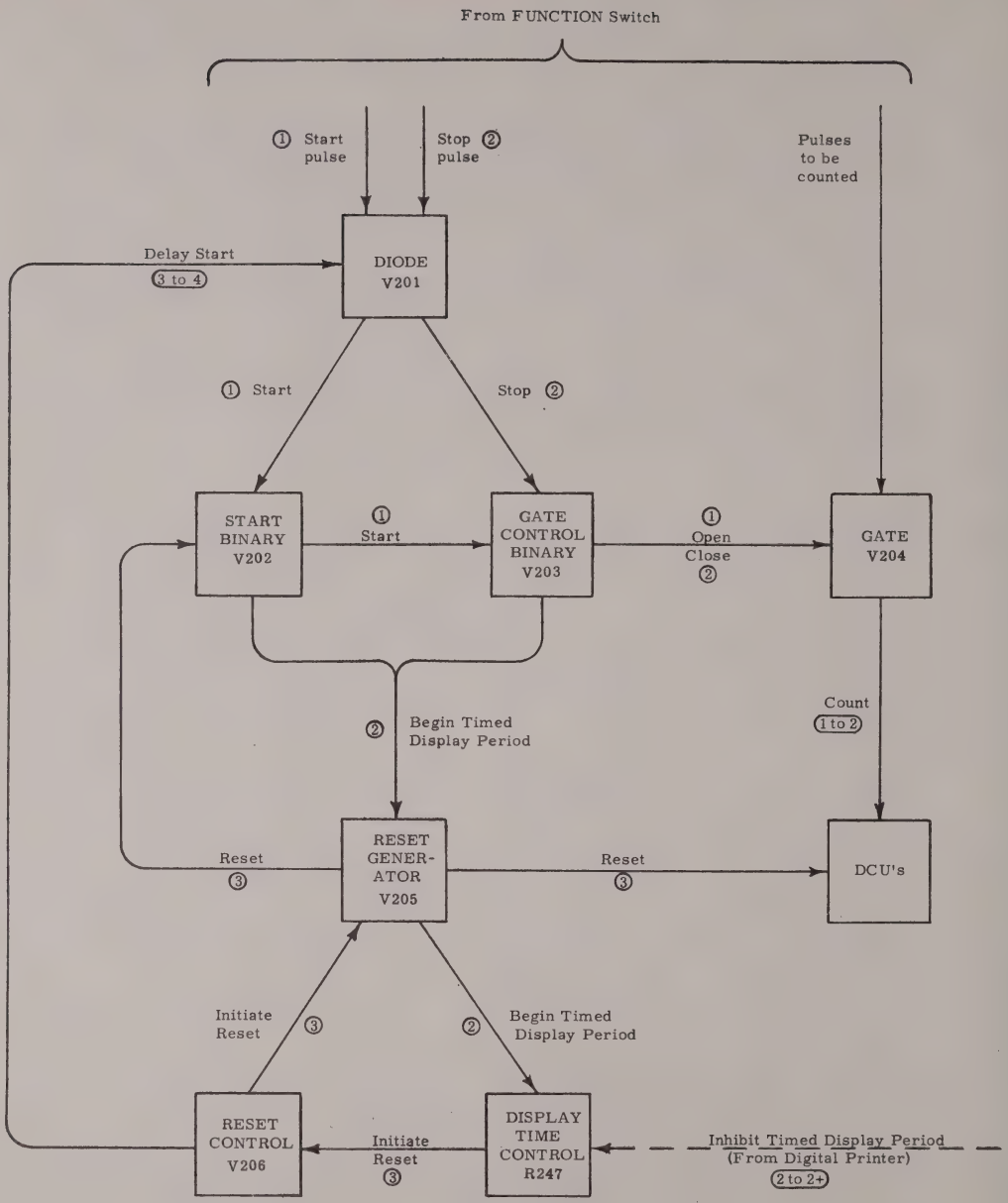


Figure 7. Control Circuit Timing Diagram

WHEN COUNTER IS NOT EQUIPPED WITH DIGITAL PRINTER



NOTE: Circled numbers indicate time of operation as labeled on the Timing Diagrams.

Figure 8 Functional Diagram of Gate and Control Circuitry

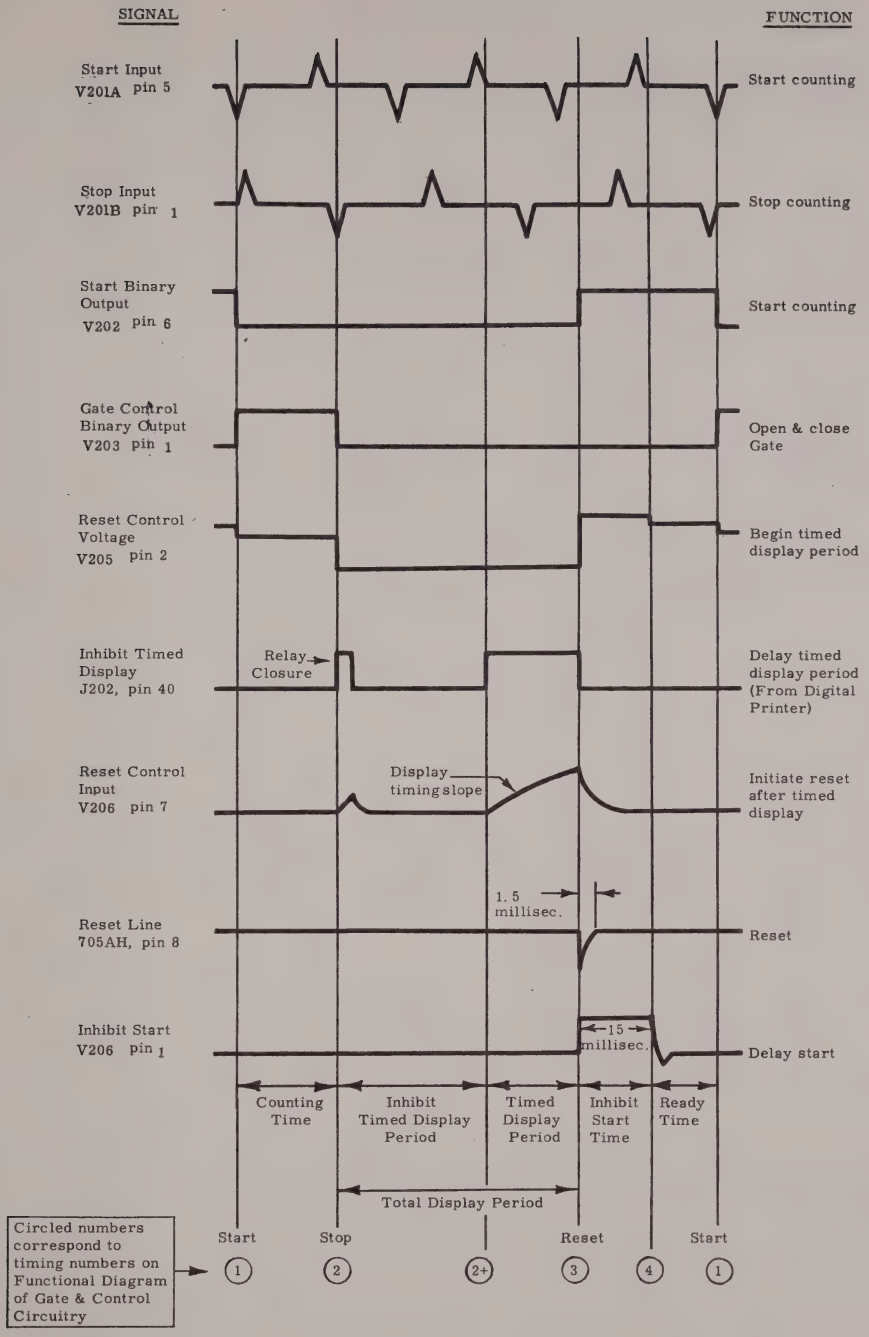


Figure 9 Control Circuit Timing Diagram

WHEN COUNTER IS EQUIPPED WITH DIGITAL PRINTER

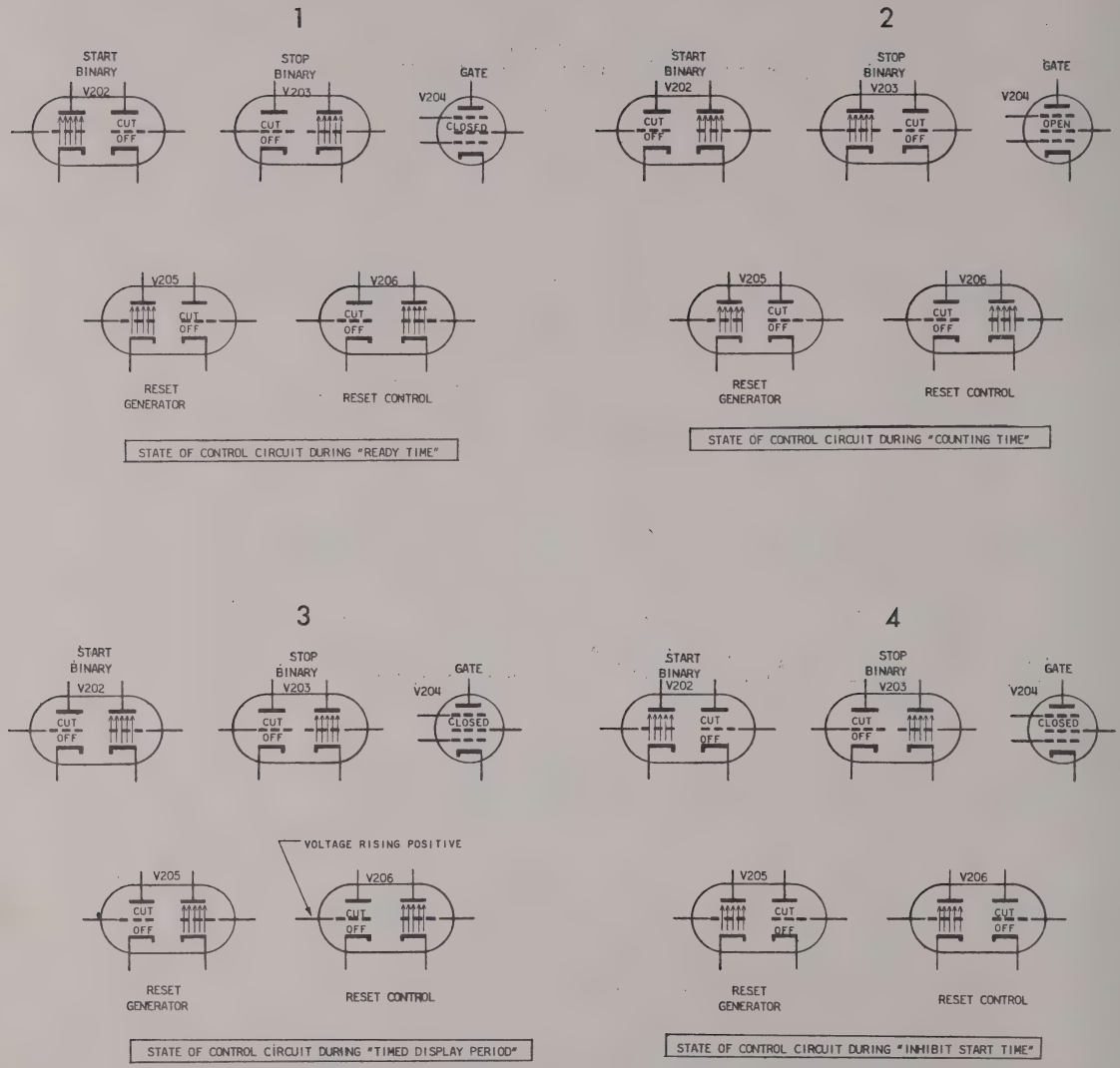


Figure 10 Tube States During the Operating Cycle

INPUT TRIGGER CHANNELS

The input trigger channels are identical. Each channel produces an output pulse each time the attenuated input signal passes a selected voltage level. The output is independent of input waveform. The channel consists of a Schmitt trigger voltage discriminator preceded by a two-stage comparator amplifier. Each input channel is preceded by an attenuator, which divides the input voltage by 1, 10 or 100 according to the position of the ATTENUATION control. The input impedance at all positions is about 10 megohms in parallel with 40 $\mu\mu$f. When the ATTENUATION control is at an AC position a .01μf capacitor (C201) is inserted in series between the INPUT jack and the attenuator.

The comparator amplifier has two stages. The first is a difference amplifier whose output is portional to the input voltage on the grid of V301A minus a selected constant voltage on the grid of V301B. The TRIGGER VOLTAGE potentiometer (R318) varies the voltage on the grid of V301B between -1 and +1 volts. The second stage (V302) amplifies the double-ended signal received from V301 and converts it to a single-ended low impedance output at the left hand plate. This plate is connected to the input grid of the discriminator.

The voltage discriminator (V303) produces an output pulse each time the input voltage on its left-hand grid passes through a fixed voltage level (about+60 volts). Consider the input to this circuit as an a-c triggering signal superimposed on d-c level. The a-c signal is an amplified reproduction of the voltage variations on the grid of V201A, that is, the attenuated input. The d-c level is determined by the voltage on the grid of V301B, a voltage set by the TRIGGER VOLTAGE potentiometer. As the TRIGGER VOLTAGE control is rotated toward "+", the d-c level is lowered and the discriminator triggers at a higher instantaneous voltage of the a-c signal and at a higher attenuated input voltage to the channel. When the TRIGGER VOLTAGE control is turned toward "-", the channel triggers at a lower attenuated input voltage.

The discriminator (V303) is a two stage positive feedback amplifier. Feedback from the output stage occurs through the cathode coupling. The loop gain is slightly greater than one so that the circuit is regenerative and tends to assume one of two stable stages. The output stage draws a steady current as long as the input grid remains below a certain triggering voltage. When the input exceeds this voltage the output tube is suddenly cut off. When the input voltage returns to a value slightly below the initial triggering voltage the output stage builds rapidly to its original steady current.

The difference between the level at which a positive-going voltage change triggers the circuit and the lower level at which a negative-going voltage change re-triggers it is called the hysteresis of the circuit. At the input to the comparator amplifier the hysteresis is about 0.3 volts. The hysteresis determines the input sensitivity. An attenuated input signal weaker than 0.3 volts peak-to-peak or about 0.1 volts rms will not trigger a series of pulses. This means that any noise at the attenuated input below this level will not trigger extraneous pulses, although it may affect the time at which a pulse occurs.

The primary winding of T301, differentiates the rapid current changes in the output stage to produce a positive pulse at the plate when the circuit is triggered by a positive-going voltage and a negative pulse when triggered by a negative-going voltage. The secondary of T201 produces inverted pulses - - a negative pulse when the circuit is triggered on a positive slope and a positive pulse when triggered on a negative slope.

DCU DIVIDER

Deck A of the FUNCTION switch (S201A) selects the signal which is divided by the DCU Divider (AY 201). During all operations other than "times ten" (x10) operations the output of the last 705AH DCU (AY 202) is coupled to the input of this divider and it functions as the last in the chain, raising the maximum count indication to 10,000,000 on the Model 7360 or to 1,000,000 on the Model 7350. During "times ten" operations the source of "start-stop" pulses is coupled to this divider through a two stage amplifier (V207), and the output of the divider becomes the "start-stop" input to the Control Circuitry. Since it produces an output pulse at every tenth input pulse, the time interval during which pulses are counted is ten times as large as it would be if the source of "start-stop" pulses drove the Control Circuitry directly. This DCU will not divide a frequency above 100 KC because its pulse resolution time is about 10 μseconds.

When the divider is part of the counting chain, Deck B of the FUNCTION switch (S201B) couples the reset pulse to pin 8 of the DCU Plug so that it resets to zero. During "times ten" operations Deck F of the FUNCTION switch connects pin 10 to -15 volts to extinguish the DCU indicator lamps and Deck D couples the reset pulse to pin 3 causing the divider to reset to nine. This is done so that the counting period will begin with the first input pulse rather than the tenth, thus eliminating an unnecessary delay.

CLOCK-PULSE GENERATOR

The Clock Pulse Generator provides

1. Pulses of a known frequency which are counted between start and stop pulses to make time measurements.
2. Start and stop pulses separated by a known time interval over which events are counted to make events-per-unit-time measurements.

The circuitry consists of an oscillator, a pulse-shaping circuit, a series of multivibrator frequency dividers, and an output trigger circuit. An additional dividing stage, the DCU Divider, is available to provide a 10-second counting period for E/UT x 10 and SCAN measurements. The shaper stage transforms the sinusoidal output of the oscillator into appropriate pulses. Each of the dividers divides the preceding frequency by ten. Decade frequencies from the shaper and the various dividers are selected by the TIME switch, shaped by the output trigger circuit (the Time Pulse Trigger) and applied to the FUNCTION switch, where they are available for start, stop or pulses to be counted.

OSCILLATOR

A crystal controlled oscillator provides a reference frequency which is divided to obtain clock pulses of various frequencies. The Model 7360 uses a 1MC oscillator and the Model 7350 uses a 100KC oscillator. In either case the oscillator consists of a two-stage amplifier with a Wheatstone bridge feedback circuit. The first stage (V401B) is a triode with an L-C tuned plate load. The triode operates as a voltage amplifier and drives the second stage V401A, a pentode which operates as a cathode follower power amplifier.

Feedback is taken from across the cathode load resistors of the pentode and fed to the inputs of a Wheatstone bridge in the cathode-grid circuit of triode. The upper arms of the bridge, consisting of R440, crystal Y401, C409 and C410, supply negative feedback to the triode grid. The lower arms consisting of RXXX and a non-linear resistor (the thermistor I401) supply positive feedback to the triode cathode. As the amplitude of the triode plate signal increases, the pentode supplies more

power to the bridge and the current through the thermistor increases raising its resistance. The higher resistance alters the voltage dividing ratio of this arm of the bridge so that less positive feedback is applied to the cathode and the amplitude of the triode plate signal is lowered. This action provides great frequency stability by limiting the amplitude of oscillation to the linear range of the circuit.

The crystal is tuned with the temperature stable capacitor C410. By adjusting the capacitor the output frequency may be shifted as much as .001%. The impedance of the crystal (Y401) varies from unit to unit. The value of RXXX has been chosen at the factory so that the voltage dividing ratio of the bridge will produce the proper amount of feedback. The triode plate circuit (L401, C403) is tuned to resonance at the oscillator frequency.

SHAPER

The shaper stage (V402) amplifiers and shapes the oscillator output for use as an input to the control circuitry and the dividers. The circuit is a voltage discriminator which operates in the same way as that discussed under "Input Trigger Channels". The trigger voltage level is set by adjusting R414. L402 differentiates the rapid current changes at the output plate to produce fast positive and negative pulses. The negative transients drive the first divider through the twin diode V602. The pulse output is conducted to the TIME switch (where it may be selected to drive the Time Pulse Trigger) and directly to the FUNCTION switch where it provides pulses to be counting during the TEST operation and a start pulse for the COUNT operation.

DIVIDERS

The dividing chain consists of cascaded monostable multivibrators. Each produces one output pulse for every ten input pulses. The Model 7350 has five dividers which scale its 100KC oscillator frequency to 1 cps. The Model 7360 carries another divider preceding the last five which scales its 1MC oscillator frequency to 100KC. Although the 1MC divider (V501, V502) carries additional circuitry to fit it for high-speed operation, it operates in essentially the same way. The action is described with reference to V604. With no input the circuit is stable; the right-hand side is conducting because its grid is connected to +120 VDC and the left-hand side is cut off. A negative transient reaching the input capacitor (C605) is coupled through R617 and R618 to each of the two plates. The negative pulse produced on the left plate is coupled by C609 to the right grid. It appears as an amplified positive pulse at the right plate, which is coupled to the left grid through C607. The left-hand side of the tube conducts, driving the left plate and the right grid even further negative. This regenerative action produces a quasi-stable stage in which the right side is cut-off and the left side is conducting. In this state the voltage on the right grid (called the "timing grid") is rising relatively slowly as the voltage at the wiper of potentiometer R656 charges the timing capacitor (C609) through R 645. At the same time negative input pulses at the right plate reach the left grid through C607 and appear as large positive pulses at the left plate. These pulses reach the timing grid through C609 and appear superimposed on the rising voltage curve there. (See Figure 11). When one of the positive pulses brings the timing grid above cut-off, the right side conducts and a reverse regenerative action returns the circuit to its original stable state. The slope of the rising grid voltage curve determines which of the successive positive pulses will rise above cut-off. The slope changes when the charging voltage at the wiper of R656 is raised or lowered. R656 is adjusted so that the ninth pulse rises above cut-off. The tenth pulse returns the circuit to the quasi-stable state.

In the interval between the ninth and tenth pulses the right side is conducting and the right

plate is negative. The negative transient produced is the useful output of the divider. It drives the next divider stage through C609 and is conduced to the TIME switch where it is available as a clock signal.

The additional circuitry associated with the 1MC divider (V501) speeds up its response. V501 is a multivibrator which operates just as V604. V502A is a cathode follower inserted between left plate of the multivibrator and timing grid. Its function is to discharge C504, the timing capacitor, within the brief 1 μsecond output pulse period so that the capacitor will pass the next positive pulse to the grid. V502B functions as a diode clamp on the left grid of the multivibrator. It prevents this grid from going so far negative during the 1 μsecond pulse output period that it will not rise above cutoff when the next positive pulse reaches it.

TIME PULSE TRIGGER

The TIME switch selects a negative output transient from one of the dividers stages and feeds it to the Time Pulse Trigger (V601). The Time Pulse Trigger is a voltage discriminator which operates in the same way as that described under "Input Trigger Channels". Output clock pulses produced at L601 are coupled to the FUNCTION switch.

POWER SUPPLY

A conventional system consisting of a transformer, two selenium bridge rectifiers and a filter network produces the +190 and -110 volt unregulated supply. Ripple on these supplies is about 10%.

The regulated +120 volt supply is obtained by dropping 190 volts through V102. The voltage drop across V102 is controlled by V101 in such a way as to maintain a constant voltage at the regulated output. A voltage dividing network (R106, R107 R113) is connected between the regulated supply and a point held 60 volts negative of ground by a

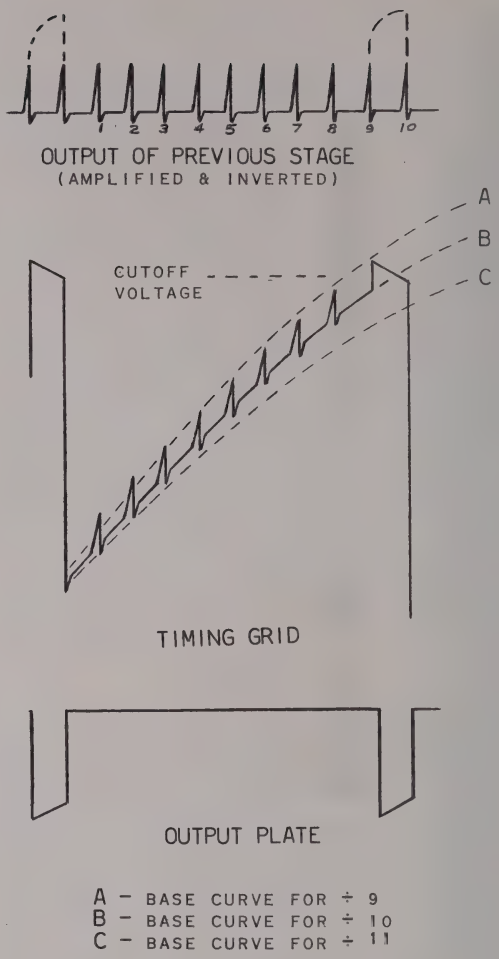
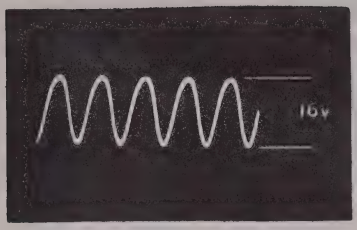


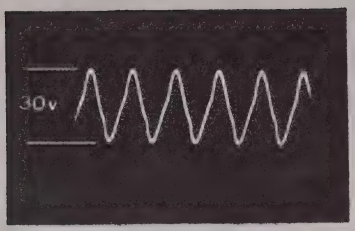
Figure 11 Divider Stage Waveforms

diode (CR103). The control grid of V101 is connected to a point on this network which is slightly below ground when the regulated supply is 120 volts. When the regulated supply varies from 120 volts, the voltage on the control grid varies proportionately and V101 delivers a signal to V102 which opposes the change.

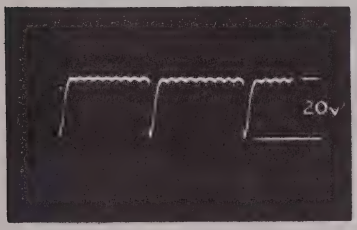
The -60 volts supply is shunt regulated by V104. Since this tube operates as a cathode follower the output voltage drawn from the cathodes remains very near the 60 volts maintained on the grids by the diode.



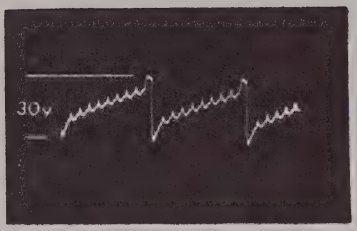
1. 1 MC Oscillator Output
V402, pin 2



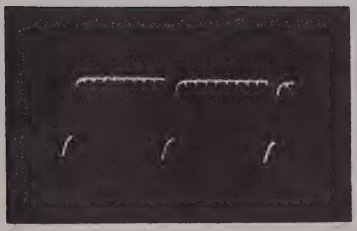
2. Shaper output, V402 , pin 1



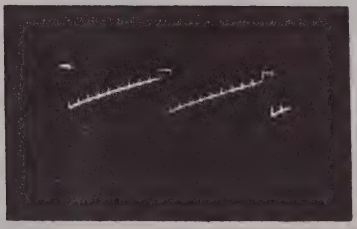
3. 1MC Divider Output Junction
of R502 and R503 (Not on Model 7350)



4. 1MC Divider timing grid.
V501 pin 2 (Not on Model 7350)

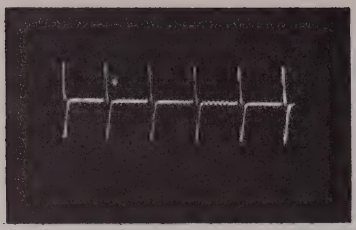


5. 100KC Divider Output
V603 . pin 6

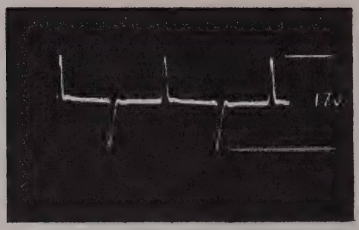


6. 100KC Divider, Timing Grid
V603, pin 7

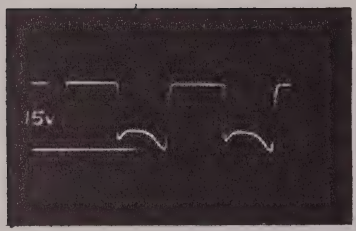
Figure 12a Typical Waveforms



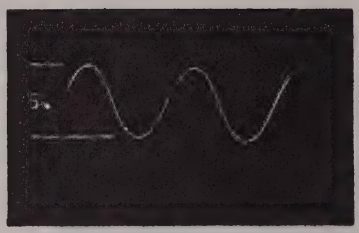
7. Time Pulse Trigger
100 KC output, V601, pin 1



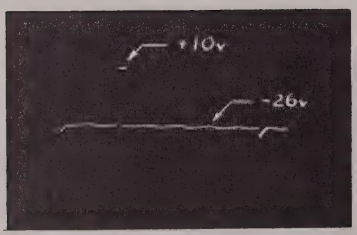
8. Discriminator output
V303, pin 1



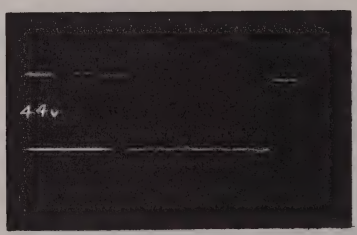
9. Discriminator amplifier plate.
100 KC signal V303, pin 6



10. Discriminator input. 100 KC
signal, V303, pin 6

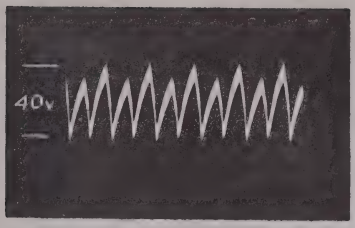


11. Gate Control Binary output.
V203, pin 1

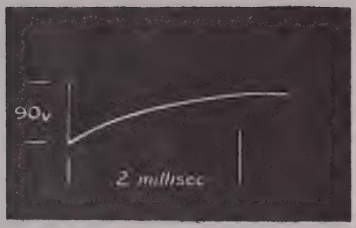


12. Start Binary output.
V202, pin 1

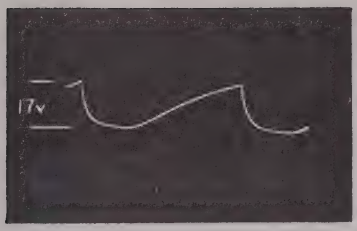
Figure 12b Typical Waveforms



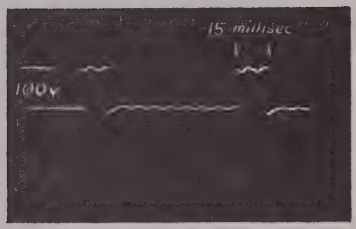
13. Signal gate output.
1 MC signal. V204, pin 5



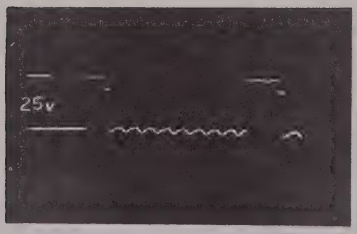
14. Reset pulse. Junction of
C215 and CR205



15. Reset Control input.
V206 pin 7

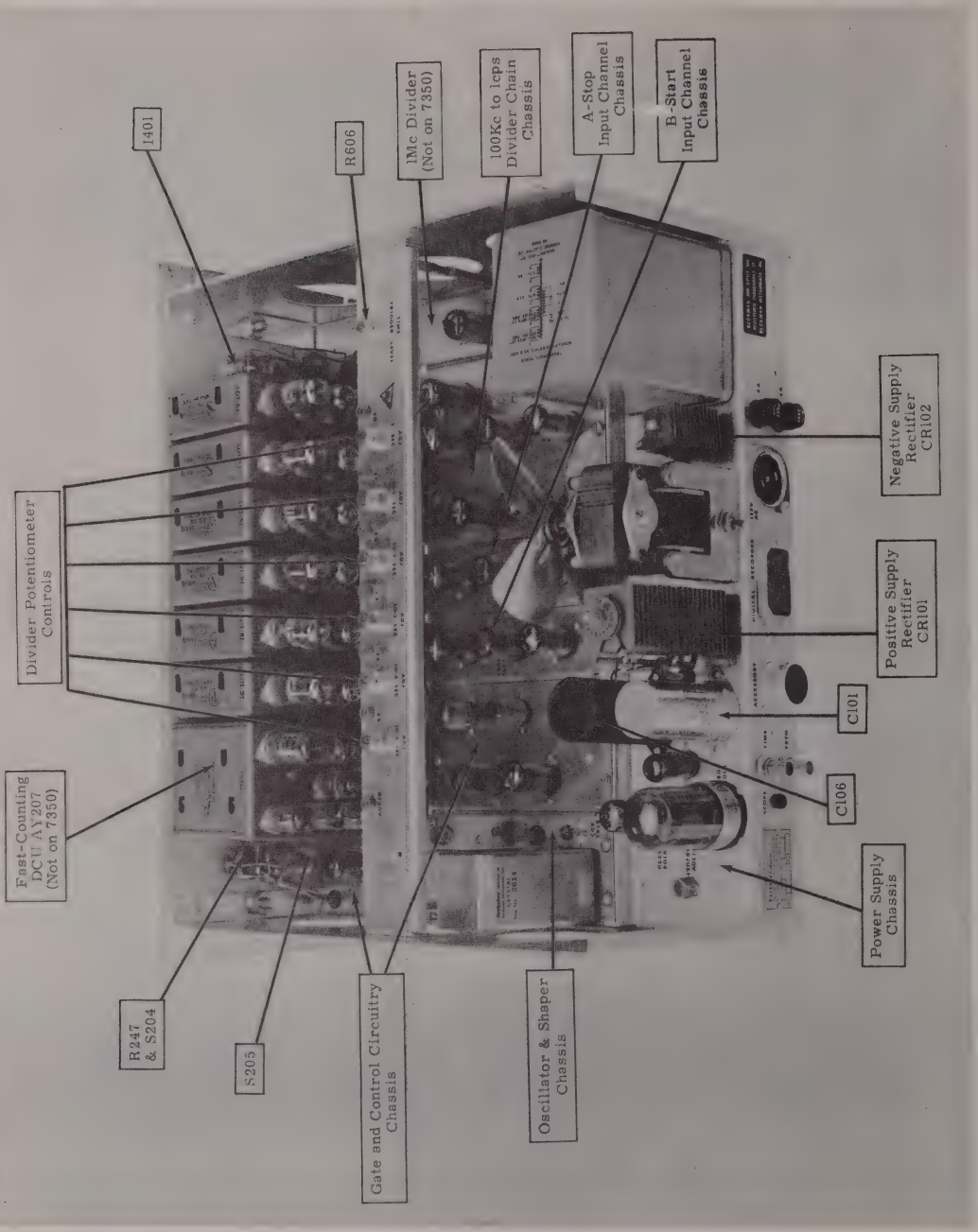


16. Reset Control output.
(minimum display time)
V206, pin 1



17. Reset Control signal to
Digital Recorder.
J202, pin 39

Figure 12c Typical Waveforms



Interior View Of Model 7360

4 Maintenance

ROUTINE ADJUSTMENTS

OSCILLATOR

The oscillator frequency can be varied by rotating the XTAL ADJust control on the top side of the counter chassis. Adjust the control until the oscillator signal which appears at the FREQuency jack comes to zero beat with a WWV signal or some other highly accurate frequency standard.

The oscillator is adjusted to maximum stability by a slug-tuned inductor (L401) in the plate circuit of the oscillator triode (V401B). Do not use this control to vary frequency. L401 is located on the under side of the chassis near the SHAPER LEVEL potentiometer. Normally, an adjustment is required only when a tube or some other component has been changed. Adjust the slug very carefully for a maximum signal at pin 6 of V401A.

A third oscillator adjustment should be made whenever the crystal is replaced. Observe the signal at pin 6 of V401A with an oscilloscope. Vary the resistance of RXXX by adding resistors in series or parallel until the positive peak of the sinusoidal waveform is flattened just enough to be noticeable.

SHAPER

The shaper stage in the clock-pulse generator is a voltage discriminator similar to those in the Input Trigger Channels. The SHAPER LEVEL control, located on the top side of the counter chassis, sets the trigger voltage at the input to this circuit. To adjust, set the FUNCTION switch at TEST. Find the limits of the range of adjustment in which the instrument continues to count. Set the control at the center of this range.

DIVIDERS

If the instrument fails to indicate correctly with the FUNCTION switch at TEST, one or more dividers may be out of adjustment. Some Model 7360 instruments may read "9" with the TIME switch at 10^{-5} and "99" with the switch at 10^{-4}. These readings are correct provided the unit reads "999,999" or "1,000,000" at the 1 second position. Dividers should be adjusted using the potentiometer controls located under the cabinet lid and labeled "ADJ 1 SEC; ADJ 10^{-1} SEC;" etc. To adjust, place the FUNCTION switch at TEST, then follow the procedure for the model you are servicing.

Adjustment procedure for Model 7350.

1. Turn TIME switch to 10^{-4} and measure the d-c voltage between test point E4 and ground. Rotate the ADJ 10^{-4} SEC control to the extremes of the range in which reading of 10 appears on the DCU's, noting the test point voltage at each extreme. Then adjust the control until the test point voltage is midway between the extreme values.
2. Turn TIME switch to 10^{-3}. Measure voltage at E3. Rotate ADJ 10^{-3} SEC control to extremes of range which reads "100", noting test points voltages at extremes. Adjust control until voltage is halfway between extremes.
3. With TIME switch at 10^{-2}, set ADJ 10^{-2} SEC control similarly but to center of voltage range in which either 1000 or 999 appears. (See step 4.)
4. Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, and the 100,000 or 99,999 range.

Adjustment procedure for Model 7360.

1. Turn TIME switch to 10^{-5} and measure the d-c voltage between test point E5 and ground. Rotate the ADJ 10^{-5} SEC control to the extremes of the range in which a reading of 10 appears on the DCU's noting the test point voltage at each extreme. Then adjust the control until the test point voltage is midway between the extreme values.

2. With TIME switch at 10^{-4}, rotate the ADJ 10^{-4} SEC control to the center of the range in which either 99 or 100 appears.
3. With TIME switch at 10^{-3}, rotate the ADJ 10^{-3} SEC control to the center of the range in which 999 or 1000 appears.
4. If neither of these readings can be obtained, return the TIME switch to 10^{-5} and re-adjust the ADJ 10^{-5} SEC control to the center of the range in which 9 (rather than 10) appears. Then, repeat steps 2 and 3 above.
5. With TIME switch at 10^{-3}, adjust all three controls (10^{-5}, 10^{-4} & 10^{-3}) to the center of the range in which either 999 or 1000 appears.
6. Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, the 100,000 or 99,999 range and the 1,000,000 or 999,999 range.

The adjustment of each divider affects the adjustment of the others slightly. Therefore, after the initial adjustment outlined above, a final adjustment should be made. With the FUNCTION switch at TEST, set the TIME switch to 10^{-1}.

On the Model 7360, a reading of 100,000 or 99,999 will appear. Adjust in turn ADJ 10^{-5} SEC thru ADJ 10^{-1} SEC to the center of the corresponding test point voltage range within which either of these readings appears. Then, set the TIME switch at 1 and rotate ADJ 1 SEC to the center of the voltage range at E0 within which either 1,000,000 or 999,999 appears.

On the Model 7350, a reading of 10,000 or 9,999 will appear. Adjust in turn ADJ 10^{-4} SEC thru ADJ 10^{-1} SEC to the center of the corresponding test point voltage range within which either of these readings appears. Then move the TIME switch to 1 and rotate ADJ 1 SEC to the center of the voltage range at E0 within which either 100,000 or 99,999 appears.

REGULATED 120 VOLT SUPPLY

Measure the supply voltage at the test point labeled "+120V" with an accurate voltmeter. Adjust +120V" with an accurate voltmeter. Adjust +120V ADJUST, located on the top side of the counter chassis, for a reading of 120 volts.

TIME PULSE TRIGGER

The Time Pulse Trigger (V601) is a Schmitt trigger circuit. The TIME TRIGGER LEVEL control varies the instantaneous voltage at which an input signal triggers the circuit from one state to another. Whenever the tube is replaced, adjust the control until, with no input signal, the potential on the input grid (Pin 2) is -1 volts with respect to the cathode (pin 7). Check TEST operation under two conditions: (1) line power reduced to 105 volts and TIME switch at 1 second (2) normal line voltage and TIME switch at 10^{-6} seconds. An incorrect adjustment will cause either a reading of 100,000 rather than 1,000,000 at the 1 second position or no reading instead of "1" on the 10^{-6} seconds position. If necessary, re-adjust the control until correct readings are obtained under both conditions.

ATTENUATOR ADJUSTMENTS

Two ceramic trimmer capacitors on each attenuator assembly must be adjusted properly to prevent the attenuator from distorting the input signal. When the counter chassis is upside down and the attenuator shafts are pointing at the viewer, the capacitor on the right side of each attenuator is C303 and that on the left C302. To adjust, apply a 500 cps square wave signal at one of the counter INPUT jacks. Observe the corresponding amplifier output at Pin 1 of V302 with a 100KC band-width oscilloscope. Turn the attenuator to 10 on the AC side. Adjust the input signal to about 1 volt peak-to-peak. Adjust the TRIGGER VOLTAGE control to any position in which the channel triggers. Adjust C303 for a square wave output. Then, turn the attenuation control to 100 on the AC side and adjust the input signal to about 10 volts peak-to-peak. Adjust C302 for a square wave output.

TROUBLE-SHOOTING

The following test equipment is necessary to service the instrument effectively:

1. An oscilloscope, sensitivity 1/4 volt, bandwidth 5 MC, preferably direct coupled.
2. A signal generator, frequency range 100 cps to 1MC, output at least 100 mv rms.
3. A vacuum tube voltmeter.

When the instrument fails to perform properly, first make sure that it is being operated correctly. Some common errors in operation are:

1. TRIGGER VOLTAGE control positioned incorrectly.
2. ATTENUATION control set incorrectly.
   (a) Wrong choice of AC or DC coupling.
   (b) Attenuated signal too strong or too weak.
3. SLOPE switches set incorrectly. (see "PERFORMING SPECIFIC OPERATIONS" for correct setting for each operation.)
4. Input signal coupled to wrong jack.
5. FUNCTION switch set at "times ten" position when original start-stop frequency is above 100 KC. For example:
   (a) FUNCTION switch at E/UT x 10 and TIME switch at 10^{-6}.
   (b) FUNCTION switch at A/B x 10 when B frequency is above 100 KC.
6. Wrong TIME switch setting
   (a) Unit of time measurement too large to measure a brief period under PERIOD operation.
   (b) Time interval too short to measure a low frequency under events-per-unit-time operation.
7. Too much noise on input signal.

When it is certain the instrument is functioning improperly, first check the power supply voltages to see that they lie within the limits listed below.

Supply	Limits of average level	Acceptable ripple
Unreg. pos.	+190v ±10%	15v peak-to-peak
Unreg. neg.	-110v ±10%	5v peak-to-peak
Reg. Pos.	+120v to accuracy of adjustment	0.1v peak-to-peak
Reg. Neg.	-55v to -65v	0.5v peak-to-peak

If the supply voltages are adequate, the next step is to trace the failure to one of the major components. This can be done by observing the start, stop and count pulses at Decks C, E & G respectively of the FUNCTION switch. If the signals at these points approximate the proper output waveforms of the pulse sources, the trouble lies in the Gate and Control Circuitry or the indicating DCU's. Refer to the schematic diagram, Figure 13, to determine the source of pulses when the FUNCTION switch is in a particular position. If a deficient pulse is found the trouble lies in that pulse source.

When the trouble has been traced to one of the major components consult the Circuit Description section of this manual and the waveforms of Figure 12 for guidance in locating the specific fault. The Input Trigger Channels may be conveniently checked by observing whether or not a pulse is produced as the TRIGGER VOLTAGE control is rotated from one extreme to the other and back.

Tubes, chokes, germanium diodes and pulse transformers are the most common sources of trouble. A transconductance tube tester will not always detect a faulty tube and, conversely, the tester may reject a tube which is functioning

properly. Although the circuits are designed for wide tube variation, avoid swapping tubes or wholesale replacement. An aged tube is generally more reliable than a new tube, because catastropic failure usually occurs early in the life of a tube if at all. An aged tube undergoes only a gradual loss of transconductance, emission, etc.

The Sylvania 6U8 tube is recommended for use in trigger circuits V402, V601 and V303. (There are two V303 stages -- one in each input trigger channel.)

PREVENTIVE MAINTENANCE

Since a tube tester will not detect tubes which are likely to cause trouble and it is undesirable to replace tubes wholesale as they grow old, other methods must be used to forestall failures. The most effective method is "marginal checking". In its simplest form this consists in causing intermittent or latent failures to manifest themselves by operating the instrument at exceptionally high or low line voltages. A variable auto-transformer may be used to manipulate the line voltage.

6 Modifications

NOTE: Modified instruments are identified by a letter or letters after the model number. For example, the Model 7150 D is a standard Model 7150 Eput Meter modified as described below under "Modification D". An instrument may be modified in more ways than one; for instance, the Model 7150DK is a Model 7150 changed in accordance with both "Modification D" and "Modification K". The entire instruction manual except this section on modifications describes a standard instrument.

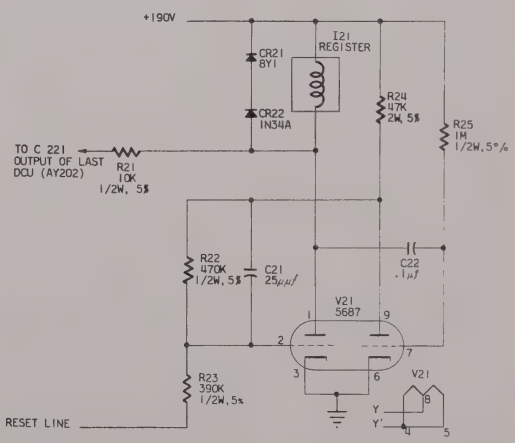
MODIFICATION B

This consists of adding a dual-purpose decimal counting unit to 7000 Series instruments which do not normally contain such a unit. Depending on the position of the FUNCTION switch, this DCU either extends the count capacity by a factor of 10 or divides the frequency of the pulses which start and stop counting by 10. This modification described in greater detail under "DCU Divider" in the "Circuit Description" section of this manual.

MODIFICATION C

This consists of the addition of a mechanical register which will extend the counting capacity of any 7000-series instrument by a factor of 10^3. Instead of using the electronic signal which resets the DCU's, the register is reset by a small lever on the front panel directly below the mechanical count-indicating dials.

On instruments with "X10" positions on the FUNCTION switch, the indicating panel of the DCU Divider (AY201) is not exposed to view when the C modification is made. The digit normally displayed by AY201 is shown at the right-hand digit of the register dial. AY202, the last exposed DCU next to the register, drives V21, a one-shot multivibrator. Each time this is activated a count is recorded on the mechanical register, the coil of which is the multivibrator plate load. When AY202 resets, a counting pulse may appear in the output. To counteract this, the reset line is connected to control-grid pin 2 of V21, so that whenever a reset pulse causes a count from AY202 to appear on the plate pin 1 of V21, the reset pulse also appears at the grid. The two pulses, opposite in polarity, counteract each other so that no count is recorded at the register.

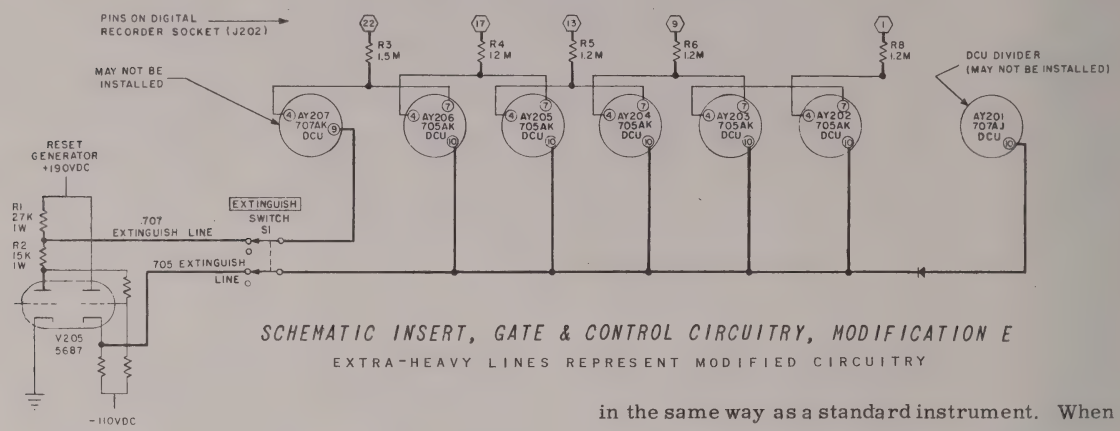


SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY, MODIFICATION C

MODIFICATION D

This consists of substituting a 100Kcs heated crystal in the oscillator of the clock-pulse generator in place of a 100Kcs unheated crystal. This modification is applicable only to 7000 Series instruments which normally contain an unheated crystal (for example, Models 7150 and 7250). The heated crystal has a stability of 1 part in 10^6 per day as compared with a stability of 1 part in 10^5 per day for the unheated crystal.

MODIFICATION E



SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY, MODIFICATION E

EXTRA-HEAVY LINES REPRESENT MODIFIED CIRCUITRY

This consists of replacing the standard decimal counting units with DCU's whose indicating bulbs can be extinguished automatically while the instrument is actively counting. With automatic extinguishing, the indicating bulbs light only at the end of each counting period to display the result.

The accompaning schematic insert shows how the circuitry of the standard instrument is modified. The voltage which extinguishes the DCU bulbs is supplied by the reset generator while it functions as usual in the standard automatic operating cycle. Both "extinguish lines" leading from the reset generator are at a relatively negative voltage at all times except during the display period. The relatively-negative voltage applied to the DCU's prevents the neon bulbs from lighting. The relatively-positive voltage on the "extinguish lines" during the display period permits the bulbs to light.

The EXTINGUISH toggle switch is located on top of the counter chassis. It may be exposed by lifting the top lid of the instrument. When this switch is closed the indicating bulbs are automatically extinguished as described above. When the switch is open the counter operates in the same way as a standard instrument. When counting is controlled manually (that is, by moving the FUNCTION switch from OFF to COUNT and back again) the EXTINGUISH switch should be open. Under manual control no automatic display period occurs, so the reset generator always supplies a voltage which would extinguish the indicating neons if connected to the DCU's.

All 705AH DCU's in the standard instrument are replaced by 705AK DCU's. Pin 10 of the DCU socket is connected to an "extinguish line" instead of to a pin in the DIGITAL RECORDER socket. The DIGITAL RECORDER pin which ordinarily connects to pin 10 is connected instead to pin 4 through a 1.2 megohm resistor.

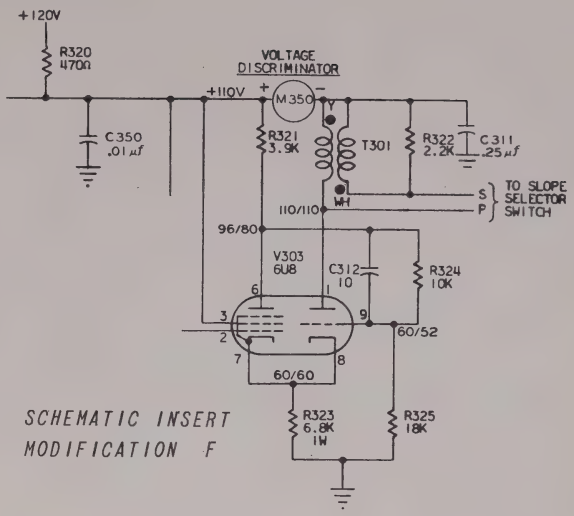
If the standard instrument has a maximum counting rate of 1 Mcs, it contains a 707AH DCU. This DCU is replaced by a 707AK DCU. An "extinguish line" is connected to pin 9 of the DCU socket, and the DIGITAL RECORDER pin which is ordinarily connected to pin 9 is connected instead to pin 4 through a 1.5 megohm resistor.

If the standard instrument is equipped with a DCU used as both a counter and a frequency divider (Model 705AJ), an "extinguish line" is connected to pin 10 of its socket.

MODIFICATION F

This consists of making modifications B, D and R plus adding a TRIGGER STATE meter to the E/UT input channel. The meter aids in adjusting the TRIGGER VOLTAGE control. The operator should adjust this control until the meter pointer stays in the center green region.

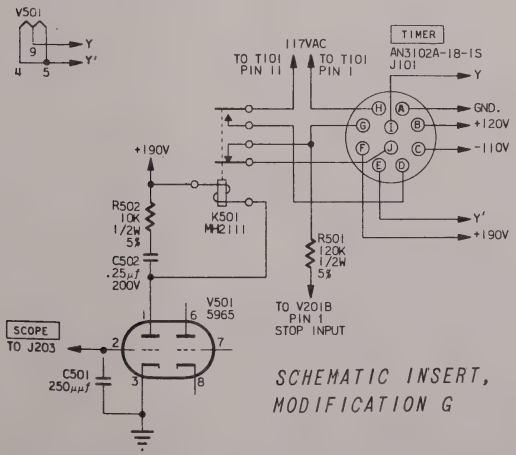
The TRIGGER STATE meter actually indicates the plate current flowing in the output triode of the voltage discriminator in the E/UT channel. This stage has two stable states: cut-off and conducting heavily. When the triode is cut-off, the meter indicates zero; when it is conducting, the meter is deflected to approximately full scale. The triode is triggered from one state to the other and back again by each input signal cycle. If the input frequency is above 10 cps the inertia of the meter will cause it to indicate the average plate current. A meter reading in the center green region indicates that the triode is cut-off half the time and conducting the other half. Under these conditions the channel produces the most reliable pulse output to be counted on the DCU's.



SCHEMATIC INSERT
MODIFICATION F

MODIFICATION G

This modification provides connections so that an external timer can be used to extend the sampling time of the counter. The labeling of J101 is changed from "ACCESSORY" to "TIMER". This socket provides 117 volt ac for operating the timer motor and it provides ground and Control Binary stop-input pin connections to the time-delay switch in the timer.



SCHEMATIC INSERT,
MODIFICATION G

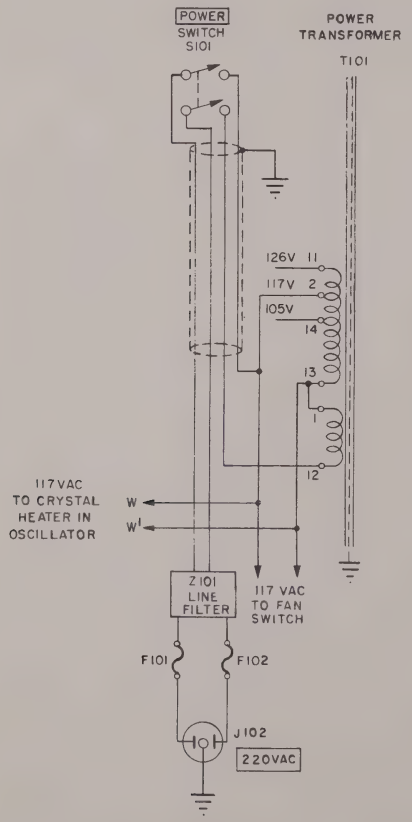
The G Modification functions with a timer in this manner. The timer dial is set to indicate a certain interval of time. A switch in the timer grounds the stop-input pin (pin 1, V201 B) of the Control Binary (V203), so that once the counter starts counting it will not stop until the stop-input pin is un-grounded. The Relay Control tube (V501) conducts and energizes relay K501 when the Signal Gate (V204) "opens". (V501 is caused to start and stop conducting by the same signals that "open" and "close" the Signal Gate--that is, the output of the Control Binary.) When the relay energizes, it closes the contacts which supply 117 volts ac to energize the timer motor. After the pre-determined time interval, the time switch opens, and the Control Binary stop-input pin is removed from ground. The next clock pulse causes the Control Binary to "close" the Signal Gate and cut off the Relay Control tube (V501). K501 is de-energized, its contacts open and remove the power from the timer motor. At this point, the timer resets.

When the external timer is not used, remove the cable from the TIMER socket and the counter will operate normally.

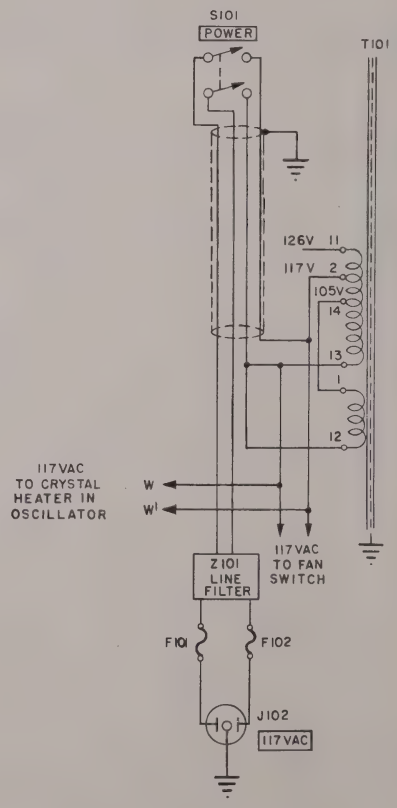
MODIFICATION H

This consists of modifying the instrument so it can be operated off a 220-volt line. The standard 117-volt power transformer is replaced by transformer having two primary windings, a 117-volt winding and a 105-volt winding. As shipped, these windings are connected in series so that when the instrument is connected to a 220-volt line, the proper voltage appears across each winding. The schematic insert below shows the modified circuitry. The line fuses (F101 & F102) in the standard counter have been replaced by fuses of one-half the standard current rating. Note that the crystal oven in the oscillator will no longer begin heating as soon as the instrument is plugged in, but will heat only when the POWER switch is on.

An instrument modified to operate on 220 volts can be reconverted to operate on 117 volts by changing the connections to the primary of the power transformer (T101) and replacing the line fuses. To do this break the connection between transformer terminals 1 and 13 and connect terminal 1 to terminal 14 and terminal 13 to terminal 12. Replace line fuses F101 and F102 with fuses of twice the current rating of those installed. The resulting circuitry is shown in the schematic insert below. Note that the 117-volt winding is connected across the line and that the 105-volt winding is connected in parallel with part of the 117-volt winding.



SCHEMATIC INSERT, POWER SUPPLY, MODIFICATION H



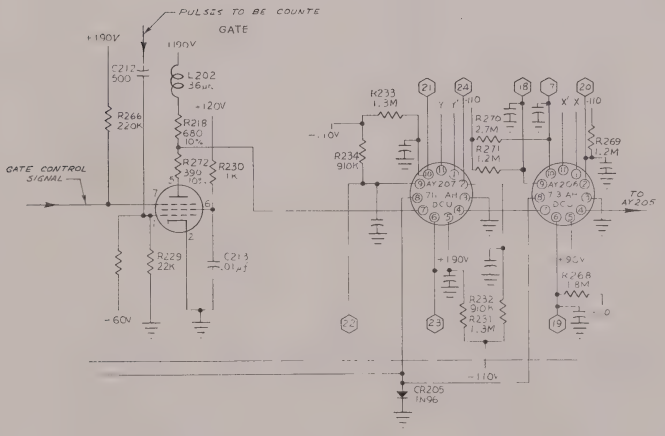
SCHEMATIC INSERT, POWER SUPPLY, MODIFICATION H RECONVERTED TO OPERATE ON 117 VOLTS AC.

MODIFICATION J

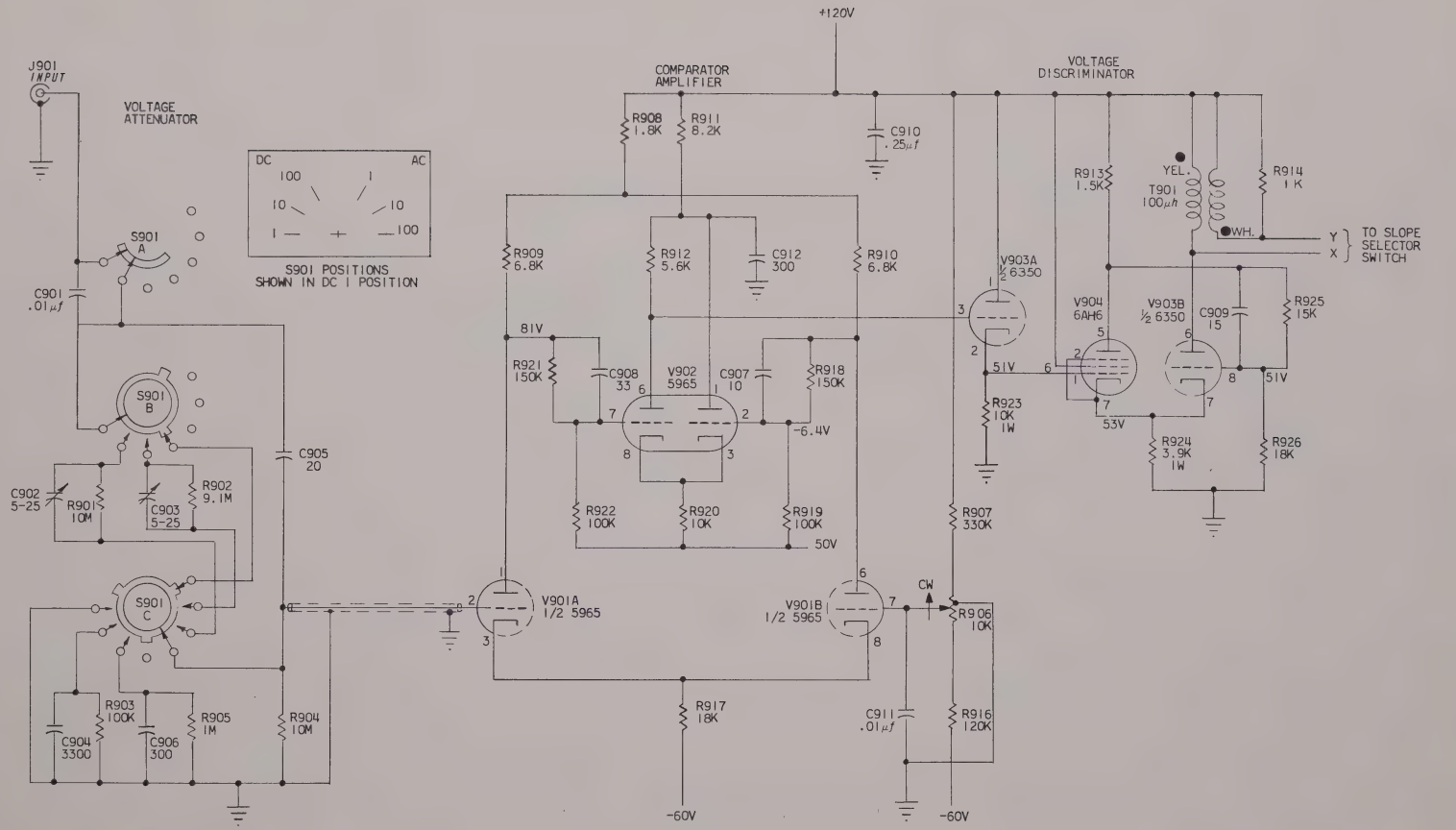
The purpose of this modification is to increase the maximum counting rate from 1Mcs to 2Mcs. To do this the first two DCU's in the counting chain are replaced with higher speed units and both input channels are modified to extend the frequency range of each to 2Mcs.

The new DCU's are the Model 711AH, which replaces a Model 707AH as AY207, and the Model 713AH, which replaces a Model 705AH as AY206. Instruction manuals on the new DCU's are located at the rear of this booklet. To accomodate this change, the circuitry surrounding the new DCU's and the gate circuitry is modified slightly, as shown in the accompanying schematic insert.

The frequency response of the input channels has been extended by inserting a cathode follower between the difference amplifier and the voltage discriminator. A schematic diagram of the modified channel appears on the following page.



SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY
MODIFICATION J



NOTE:

RESISTORS: 1/2 WATT, 5% UNLESS OTHERWISE NOTED.

CAPACITORS: IN μμf UNLESS OTHERWISE NOTED.

SCHEMATIC DIAGRAM
INPUT TRIGGER CHANNEL
MODIFICATION J.
DWG NO. 5571C7

7160 Mod J

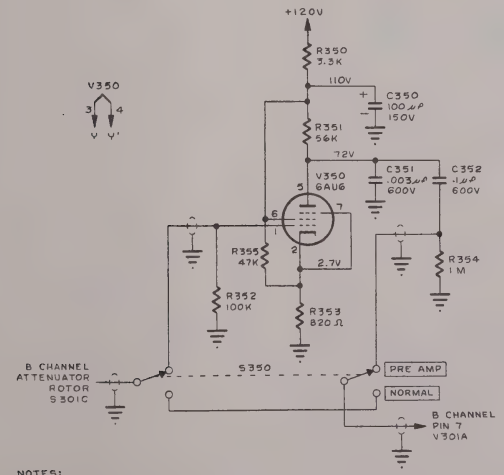
7360 Mod J

MODIFICATION K

This consists of adding a preamplifier between the attenuator and the comparator amplifier stage of the B channel. The preamplifier responds to frequencies between 3 and 1000 cps, with a sensitivity of 5 millivolts rms at 5 cps. A 7000-Series instrument with this modification has a PREAMP-NORMAL switch on its front panel. In the PREAMP position, this connects the preamplifier into the circuit. In the NORMAL position, it disconnects the preamplifier and connects the B channel attenuator directly to the comparator amplifier.

To operate, throw the PREAMP-NORMAL switch to PREAMP. At the B channel controls, turn the ATTENUATION switch to DC-1 and adjust the TRIGGER LEVEL control for maximum sensitivity.

Note that, while switched to PREAMP, the input is d-c coupled to the preamplifier and terminated in a 100K ohm resistor and the ATTENUATION switch will no longer divide the input by the values shown on the front panel. For inputs over 100 millivolts, switch to NORMAL. The preamplifier is most advantageously used with inputs which maintain constant peak voltage amplitudes. The RC time constant of the output coupling circuit is 0.1 seconds. This and the repitition rate of the input signal determine the maximum permissible drop between the peak voltage value of one input wave and the next, if both are to be counted.



SCHEMATIC INSERT, INPUT TRIGGER CHANNEL, MODIFICATION K

MODIFICATION R

This consists of simply removing the cabinet from the chassis and the attached front panel and adding dust covers-top and bottom. When this is done the counter may be mounted in a standard relay rack.

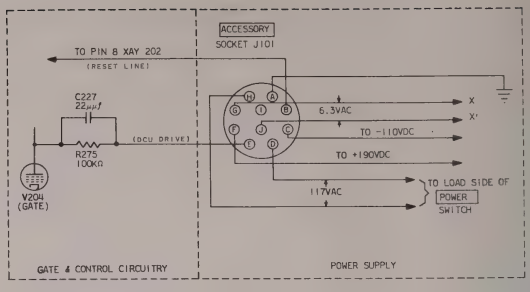
MODIFICATION T

This consists of the V modification plus a half-second clock-pulse interval in place of the usual 1-second interval. The last stage of the Frequency Divider Chain is modified from a divide-by-ten to a divide-by-five stage. This is done by changing the value of timing capacitor C617 from 0.47μfd to 0.25μfd. The extreme clockwise position of the TIME-SECONDS switch is also changed to read ".5". When using an instrument with this modification keep in mind that the maximum sampling time available is 0.5 seconds, not 1.0 seconds.

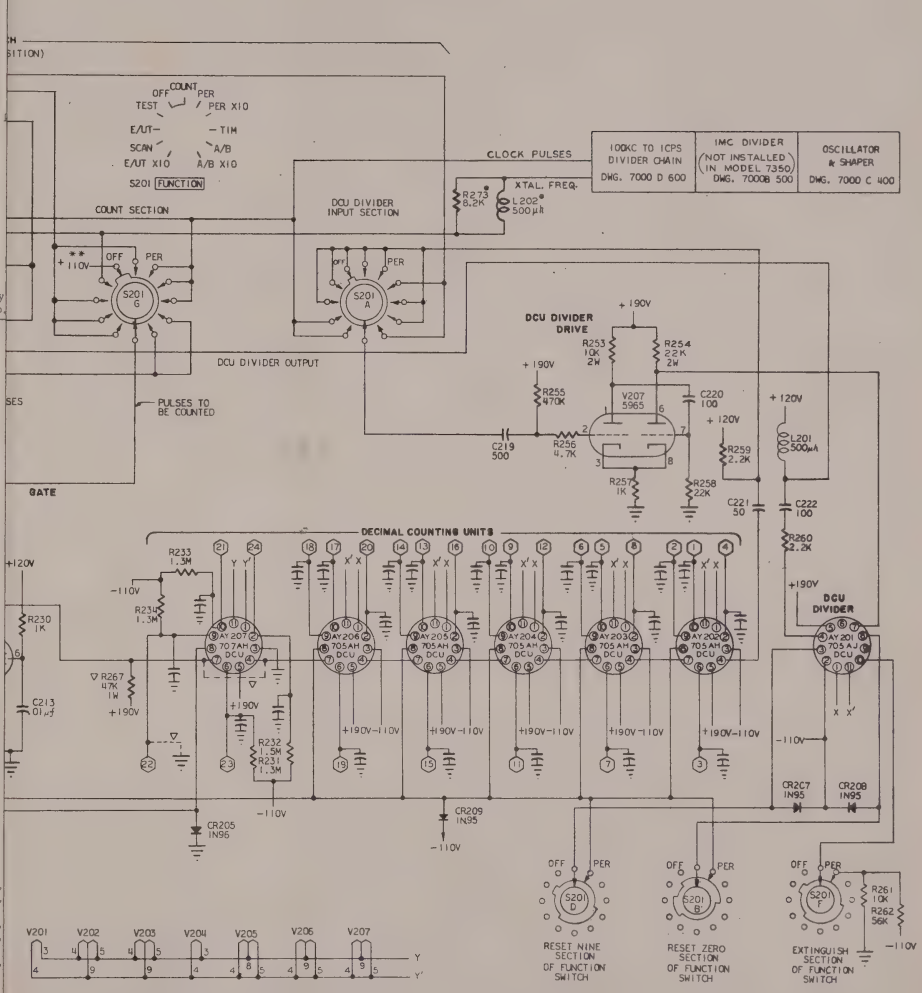
MODIFICATION V

The V modification provides DCU Drive and Reset signals as well as power at the ACCESSORY socket (J101) for operating a remote indicator consisting of several cascaded DCU's. The DCU drive signal is taken from the plate of the Signal Gate (V204). The signal is passed through a network which reduces its amplitude and its output impedance before it reaches the ACCESSORY socket. The Reset signal is taken directly from the reset line (pin 8 of the DCU's). In addition, B+ and B- voltages are available at J101, as well as 117 volts ac to power a fan and a filament transformer.

The DCU's may be removed from the counting instrument and placed in the remote indicator. If this is done there will no longer be a signal at J202, the DIGITAL RECORDER socket, for operating an accessory recorder. With the remote indicator in use, operate the counting instrument in the usual manner. When the remote indicator is not used, disconnect the indicator cable from the ACCESSORY socket.



SCHEMATIC INSERT, MODIFICATION V


CLOCK PULSES
100KC TO 1CPS DIVIDER CHAIN
DWG. 7000 D 600
1MC DIVIDER (NOT INSTALLED IN MODEL 7350) DWG. 7000B 500
OSCILLATOR & SHAPER
DWG. 7000 C 400
XTAL. FREQ.
COUNT SECTION
DCU DIVIDER INPUT SECTION
DCU DIVIDER OUTPUT
PULSES TO BE COUNTED
GATE
DCU DIVIDER DRIVE
DECIMAL COUNTING UNITS
DCU DIVIDER
RESET NINE SECTION OF FUNCTION SWITCH
RESET ZERO SECTION OF FUNCTION SWITCH
EXTINGUISH SECTION OF FUNCTION SWITCH
NUMBERS INDICATE PINS OF DIGITAL RECORDER SOCKET, J202.
PINS 1 THRU 24 OF J202 ARE BYPASSED TO GROUND WITH .001μf CAPACITOR-C223 THRU C246.
RESISTORS:
WATTAGE — ½W UNLESS NOTED OTHERWISE.
TOLERANCE — 5% UNLESS NOTED OTHERWISE.
CAPACITORS:
CAPACITY — IN μμf UNLESS NOTED OTHERWISE.
**110 VOLTAGE FROM B CHANNEL, DWG. 7000 C 300
▽ THE CIRCUITRY SHOWN IN DOTTED LINES EXISTS ONLY IN MODEL 7350. IN THIS INSTRUMENT THE 707AH SOCKET IS EMPTY.
• — INSTALLED ON 7360 ONLY.

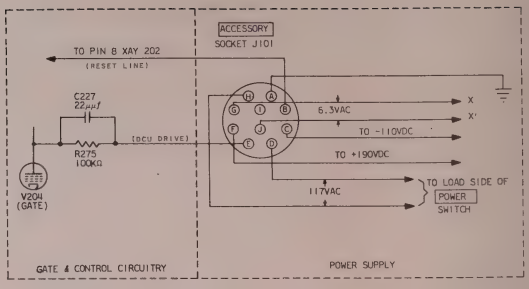
Detail No.	Berkeley Stock No.
AY201	
AY202, AY203 AY204, AY205 & AY206	
AY207	
C201	2-2137
C202	2-2138
C203	2-2760
C204	2-4388
C205	
C206	
C207	
C208	
C209	
C210	
C211	
C212	
C213	2-2230
C214& C215	2-5691
C216	2-6122
C217	
C218	
C219	
C220	2-2136
C221	2-2141
C222	2-2136
C223	2-5793
C224, C225, C226, C227, C228, C229, C230, C231, C232, C233, C234, C235, C236, C237, C238, C239, C240, C241, C242, C243, C244, C245, C246	
CR210	8-4184
L202	3-6164
R268	1-1166A

7350 LOT 13

7360 LOT 1

FIGURE 13
SCHEMATIC DIAGRAM
GATE & CONTROL CIRCUITRY
MODELS 7350 & 7360
DWG. NO. 7350D8

The DCU's may be removed from the counting instrument and placed in the remote indicator. If this is done there will no longer be a signal at J202, the DIGITAL RECORDER socket, for operating an accessory recorder. With the remote indicator in use, operate the counting instrument in the usual manner. When the remote indicator is not used, disconnect the indicator cable from the ACCESSORY socket.



SCHEMATIC INSERT, MODIFICATION V

PARTS LIST MODELS 7350 & 7360 GATE & CONTROL CIRCUITRY

Refer to Drawing No. 7350D8

ABBREVIATIONS

BDB	Berkeley Division Beckman, Richmond, Calif.
Cap.	Capacitor
CT	Center Tap
CH	Cutler-Hammer Co., Milwaukee, Wisconsin
DC	Deposited Carbon
DCU	Decimal Counting Unit
FC	Fixed Composition
GE	General Electric, Schenectady, New York
Gen. Ind.	General Industries, Elyria, Ohio
HV	High Voltage
IPC	Industrial Products Co., Danbury, Connecticut
IRC	International Rectifier Corp, El Segundo, Calif.
LV	Low Voltage
μa	Microamps
μh	Microhenries
ma	Milliamps
mh	Millihenries
Pot.	Potentiometer
RCA	Radio Corporation of America, Harrison, New Jersey
Res.	Resistor
USECO	U.S. Engineering Company, Glendale, California
VDC	Volts Direct Current
WW	Wire Wound

NOTE: Any resistor which does not appear in the list below is a fixed composition resistor of the value, wattage and tolerance noted on the schematic diagram. All other electrical components are listed.

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
AY201		DCU, Model 705AJ BDB	BDB
AY202, AY203 AY204, AY205 & AY206		DCU, Model 705 AH	BDB (not on Model 7350)
AY207		DCU, Model 707AH	Sangamo RR 1350
C201	2-2137	Cap., 500 Mmfd, Mica	Sangamo RR 1425
C202	2-2138	Cap., 25 Mmfd, Mica	Sangamo 3004025
C203	2-2760	Cap., .25 Mfd, 400 V, Paper	Sprague (2-2230 may be used)
C204	2-4388	Cap., .01 mf, Disc. Axial Lead	
C205		Same as C202	
C206		Same as C201	
C207		Same as C202	
C208		Same as C202	
C209		Same as C204	
C210		Same as C202	
C211		Same as C202	
C212		Same as C201	Erie 811
C213	2-2230	Cap., .01 mfd, Disc	Hopkins Eng. P140
C214& C215	2-5691	Cap., .1 mfd, 400 V, Metalized Paper	Sprague 2TM-M1
C216	2-6122	Cap., 1 mfd, 200 V	
C217		Same as C213	
C218		Same as C213	
C219		Same as C201	Sangamo RR 1310
C220	2-2136	Cap., 100 Mmfd, Mica	Sangamo RR 1450
C221	2-2141	Cap., 50 Mmfd, Mica	Sangamo RR 1310
C222	2-2136	Cap., 100 Mmfd, Mica	Centralab DD 102
C223	2-5793	Cap., .001 mfd, Disc.	
C224, C225, C226, C227, C228, C229, C230, C231, C232, C233, C234, C235, C236, C237, C238, C239, C240, C241, C242, C243, C244, C245, C246		Same as C223	
CR201, CR202 & CR203	8-5579	Crystal Diode, 9GA2	IRC
CR204	8-5580	Crystal Diode, 1N95	Hughes Aircraft
CR205	8-4128	Crystal Diode, 1N96	Hughes Aircraft
CR206		Same as CR201	
CR207		Same as CR204	
CR208		Same as CR204	
CR209		Same as CR204	
J202	17-5620	Connector, 40 pin Chassis Mtg.	Cannon DPX-40-34S
J203	17-3295	Connector, Jack Nylon Black	Johnson 105-603-2
R247	1-2956	Potentiometer, 10M with Switch	CRL BA026-000
S201	12-6029B	Switch, 4 sec, 4 pos, rotary	
S202 & S203	12-1909	Switch, DPDT	CH 8373K7
S204		On back of R247	
S205	12-2600	Switch, Reset DPDT Push	Switchcraft #FF1006
V201	5-0978	Tube, 6AL5	RCA
V202 & V203	5-3301	Tube, 5965	RCA
V204	5-0500	Tube, 6AS6	RCA
V205	5-2129	Tube, 5687	Tung Sol
V206		Same as V202	
V207	5-3301	Tube, type 5965	
XAY201 & XAY202, XAY203, XAY204, XAY205, XAY206, XAY207	4-1720	Socket, 11 Pin	Amphenol 77MIP11
XV201	4-2972	Socket, 7 Pin w/o Shield w/lugs	Elco 316BC
XV202, XV203	4-2973	Socket, 9 Pin w/o Shield w/lugs	Elco 377BC
XV204		Same as XV201	
XV205		Same as XV202	
XV206		Same as XV202	
XV207	4-720	Same as XV202	
	18-0776	Cable Assembly Model 776	BDB

ADDITIONS

CR210	8-4164	Diode, 1N67A
L202	3-6164	Coil, 500 Micro henry
R268	1-1166A *	8.2K, 1/2 W, 5 %

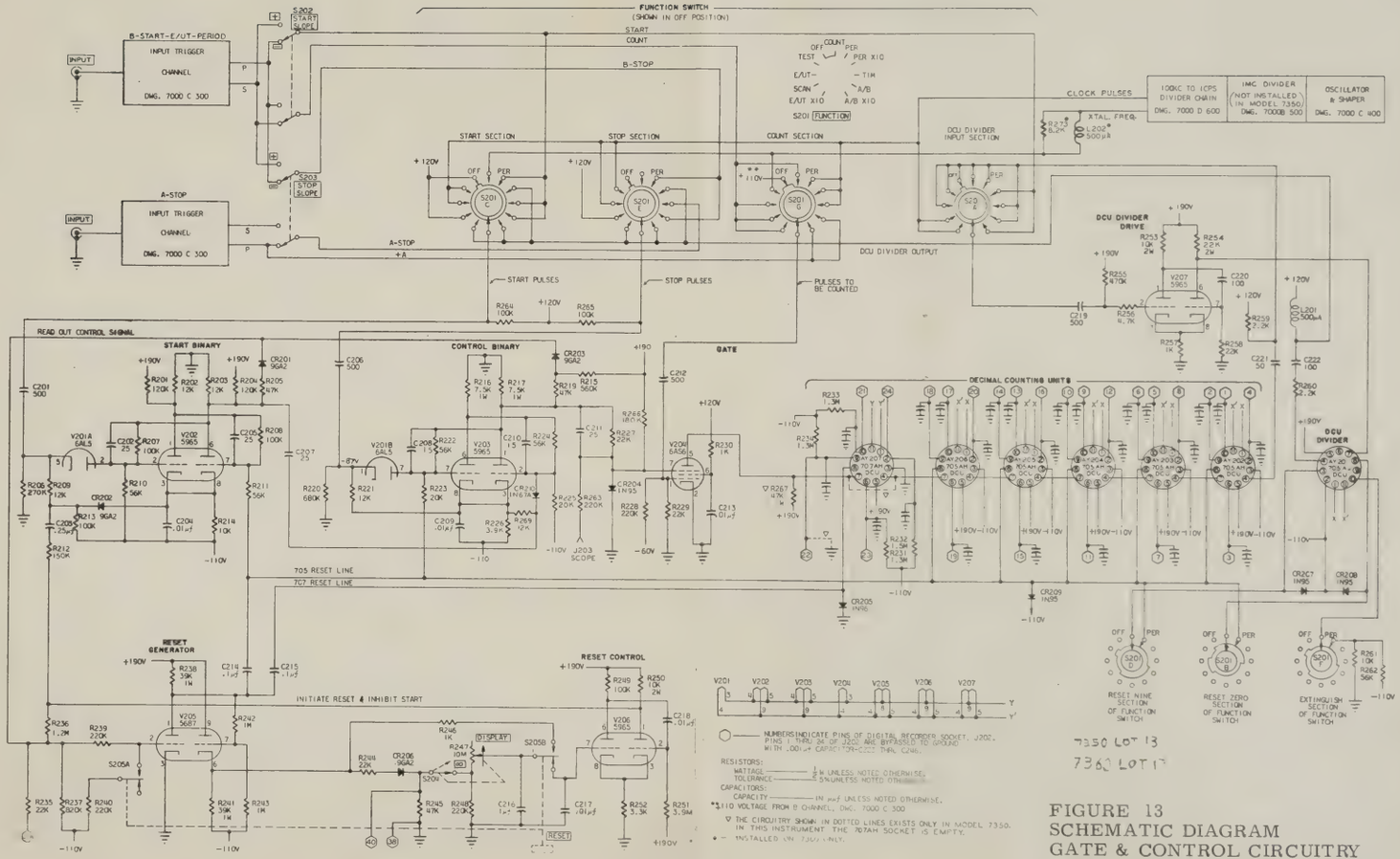
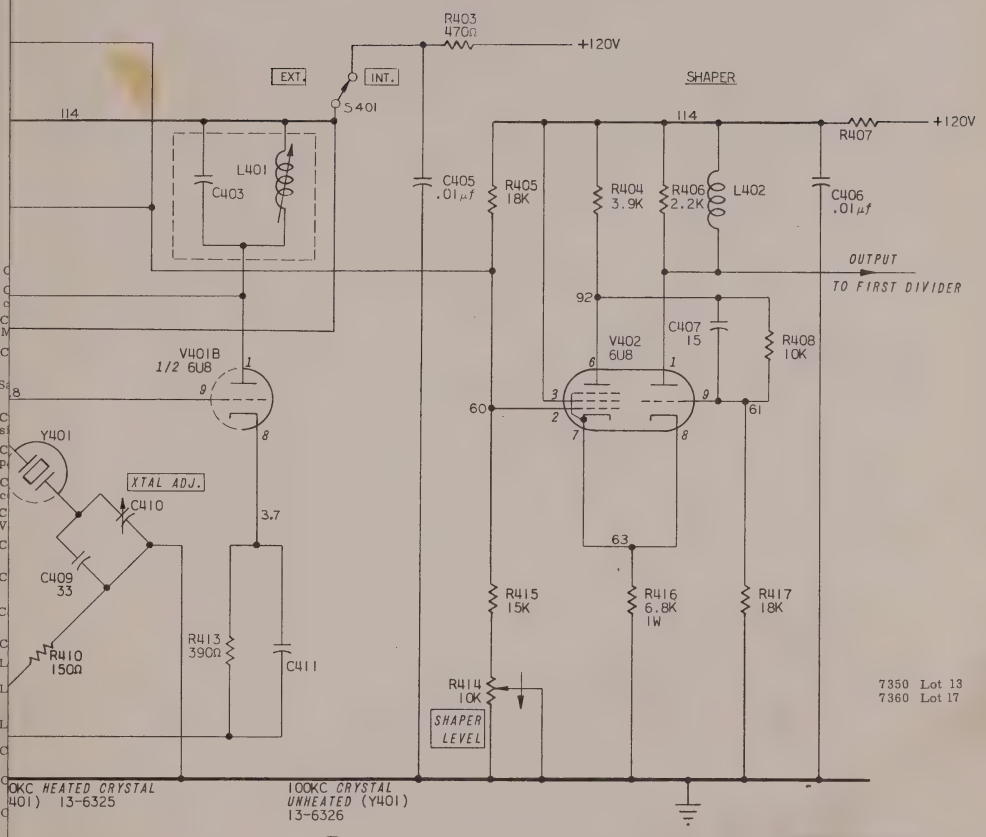


FIGURE 13
SCHEMATIC DIAGRAM
GATE & CONTROL CIRCUITRY
MODELS 7350 & 7360
DWG. NO. 7350D8



Detail No.	Stock No.	
C401	2-2230	C
C402	2-3242	C c
C403 (Model 7350)	2-3246	C M
C403 (Model 7360)	2-3620	C
C404 to C406		Si
C407	2-2135	C si
C408	2-3943	C P
C409	2-3106	C c
C410 (Model 7350)	2-1501	C V
C410 (Model 7360)	2-5706	C
C411 (Model 7350)	2-4268	C
C411 (Model 7360)	2-2230	C
C412	2-5747	C
I401 (Model 7350)	21-1677	L
I401 (Model 7360)	21-1677	L
I402	21-5861	L
J401	17-3179	C
L401 (Model 7350)	3-6344	C
L401 (Model 7360)	3-3511	C
L402 (Model 7350)	3-6397	C
L402 (Model 7360)	3-6328	C

DETAIL NO.	MODEL NO.						
	5571	7360	7260	7160	7350 & P MOD.	7250	7150
RXXX	200Ω	200Ω	200Ω	200Ω	4700Ω	1000Ω	1000Ω
C403	120μμf	120μμf	120μμf	120μμf	600μμf	600μμf	600μμf
L401	190-210μhy	190-210μhy	190-210μhy	190-210μhy	2.5-5mhy	2.5-5mhy	2.5-5mhy
Y401	13-5696	13-5696	13-5696	13-5696	13-6325	13-6326	13-6326
R418	68Ω	68Ω	68Ω	68Ω	NONE	NONE	NONE
C410	2-18	2-18	2-18	2-18	0-100	0-100	0-100
C411	.01μf	.01μf	.01μf	.01μf	5μf	5μf	5μf
L402	240μhy	240μhy	240μhy	240μhy	400μhy	400μhy	400μhy
R407	270Ω	270Ω	270Ω	270Ω	470Ω	470Ω	470Ω

* VALUE SELECTED FOR INDIVIDUAL INSTRUMENT. SEE TABLE FOR APPROXIMATE RESISTANCE.

SCHEMATIC DIAGRAM
MODELS 7360 & 7350
OSCILLATOR & SHAPER
Dwg. No. 7000C400

PARTS LIST, OSCILLATOR & SHAPER MODELS 7350 & 7360

Refer to Dwg. No. 7000C400

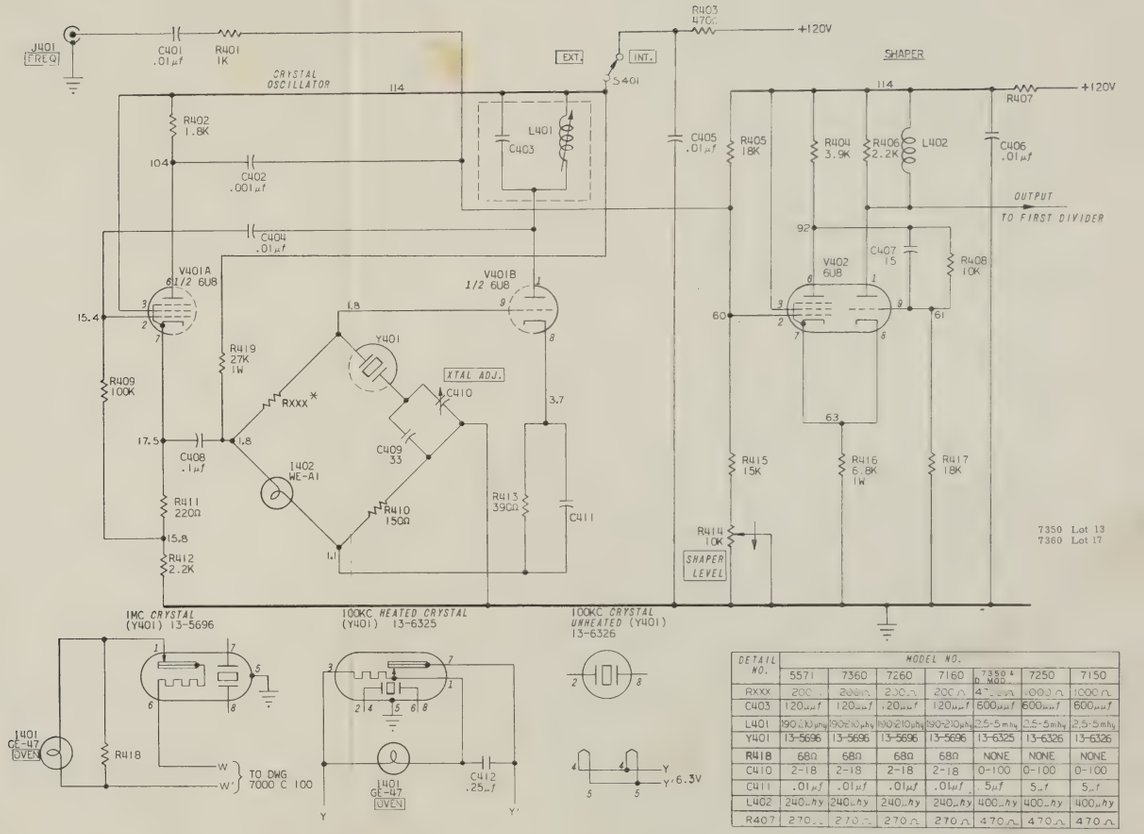
ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin
BDB	Berkeley Division Beckman, Richmond, Calif.
CH	Cutler-Hammer Co., Milwaukee, Wisconsin
FC	Fixed Composition
IPC	Industrial Products Co., Danbury, Connecticut
Pot.	Potentiometer
RCA	Radio Corportation of America, Harrison, New Jersey

Detail No.	Stock No.	Description	Manufacturer & No.
C401	2-2230	Capacitor, .01 μfd, Disc,	Erie #811
C402	2-3242	Capacitor, .001 μfd, tubular ceramic	Erie GPK
C403 (Model 7350)	2-3246	Capacitor, 600 μμfd, 500 V Mica	Sangamo KR 1360
C403 (Model 7360)	2-3620	Capacitor, 120 μμfd, Mica	Sangamo 1312
C404 to C406		Same as C401	
C407	2-2135	Capacitor, 15 μμfd, 500 vdc, silvered Mica	Sangamo RR 1415
C408	2-3943	Capacitor, .1 μfd, plastic molded paper	CD Tiny Chief
C409	2-3106	Capacitor, 33 μμfd, tubular ceramic	Erie NPO
C410 (Model 7350)	2-1501	Capacitor, 0-100 μμfd. Variable	Millen
C410 (Model 7360)	2-5706	Capacitor, 2-18 μμfd, Variable	JFD VC4
C411 (Model 7350)	2-4268	Capacitor, 5 μfd, 8 V	Barco P58-5
C411 (Model 7360)	2-2230	Capacitor, .01 μfd, 600 V Disc.	Erie # 811
C412	2-5747	Capacitor, .25 μfd, 200 V	Heco 15-390-6
I401 (Model 7350)	21-1677	Lamp # 47	General Electric
I401 (Model 7360)	21-1677	Lamp #47	General Electric
I402	21-5861	Lamp, 24 V, .033 to .045 amp.	24B-2
J401	17-3179	Connector, BNC	IPC MS 595
L401 (Model 7350)	3-6344	Choke, 2.5-5 Milli Henry	
L401 (Model 7360)	3-3511	Choke, 190-210 μ Henry	
L402 (Model 7350)	3-6397	Choke, 400 μ Henry	Wilco 1400-15
L402 (Model 7360)	3-6328	Choke, 240 μ Henry	Wilco 3240-15

Detail No.	Stock No.	Description	Manufacturer & No.
R401	1-0209A	Resistor, 1 K, 1/2 W, 5 %, FC	AB EB 1025
R402	1-2489	Resistor, 1.8 K, 1/2 W, 5 %FC	AB EB 1825
R403	1-3210	Resistor, 470 Ω, 1/2 W, 5 %,FC	AB EB 4715
R404	1-3609	Resistor, 3.9 K, 1/2 W, 5 %,FC	AB EB 3925
R405	1-1169A	Resistor, 18 K, 1/2 W, 5 % .FC	AB EB 1835
R406	1-5598	Resistor, 2.2 K, 1/2 W, 5 %,FC	AB EB 2225
R407 (Model 7350)	1-3210	Resistor, 470 Ω, 1/2 W, 5 %	AB EB 4715
R408	1-0210A	Resistor, 10 K, 1/2 W, 5%,FC	AB EB 1035
R409	1-0960	Resistor, 100 K, 1/2 W, 5%,FC	AB EB 1045
R410	1-4368	Resistor, 150 Ω, 1/2 W, 5 %,FC	AB EB 1515
R411	1-5597	Resistor, 220 Ω, 1/2 W, 5 %,FC	AB EB 2215
R412		Same as R406	
R413	1-5902	Resistor, 390 Ω, 1/2 W, 5 %,FC	AB EB 3915
R414	1-0875	Pot., 10 K, 2 W, 10 %, carbon linear	AB JU 1031
R415	1-1168A	Resistor, 15 K, 1/2 W, 5 %FC	AB EB 1535
R416	1-5079	Resistor, 6.8 K, 1 W, 5 %,FC	AB GB 6825
R417		Same as R405	
R418	1-4418	Resistor, 68 Ω, 2 W, 5 %	AB HB 6805
R419	1-0341	Resistor, 27 K, 1 W, 5 %, FC .	AB GB 2735
S401	12-1643	Switch, SPST	CH 8280K15
V401 & V402	5-2526	Tube, 6U8	RCA
XI401 (Model 7360)	4-3324	Socket, Lamp Red Faceted	Dialco 81410-410
XV401 & XV402	4-3345	Socket, 9 Pin W/Shield	
XY401	4-3213	Socket, Octal, Mica filled	Cinch Jan
Y401 (Model 7350)	13-6325	Crystal, 100 KC W/Oven	
Y401 (Model 7360)	13-5696	Crystal, 1 MC W/Oven	

ADDITIONS



DETAIL NO.	MODEL NO.						
	5571	7360	7260	7160	7350 & 7400	7250	7150
RXXX	200	200Ω	230Ω	200Ω	470Ω	400Ω	1000Ω
C403	120μμf	120μμf	120μμf	120μμf	600μμf	600μμf	600μμf
L401	190-210μhy	190-210μhy	190-210μhy	190-210μhy	2.5-5mhy	2.5-5mhy	2.5-5mhy
Y401	13-5696	13-5696	13-5696	13-5696	13-6325	13-6326	13-6326
R418	68Ω	68Ω	68Ω	68Ω	NONE	NONE	NONE
C410	2-18	2-18	2-18	2-18	0-100	0-100	0-100
C411	.01μf	.01μf	.01μf	.01μf	5μf	5μf	5μf
L402	240μhy	240μhy	240μhy	240μhy	400μhy	400μhy	400μhy
R407	270Ω	270Ω	270Ω	270Ω	470Ω	470Ω	470Ω

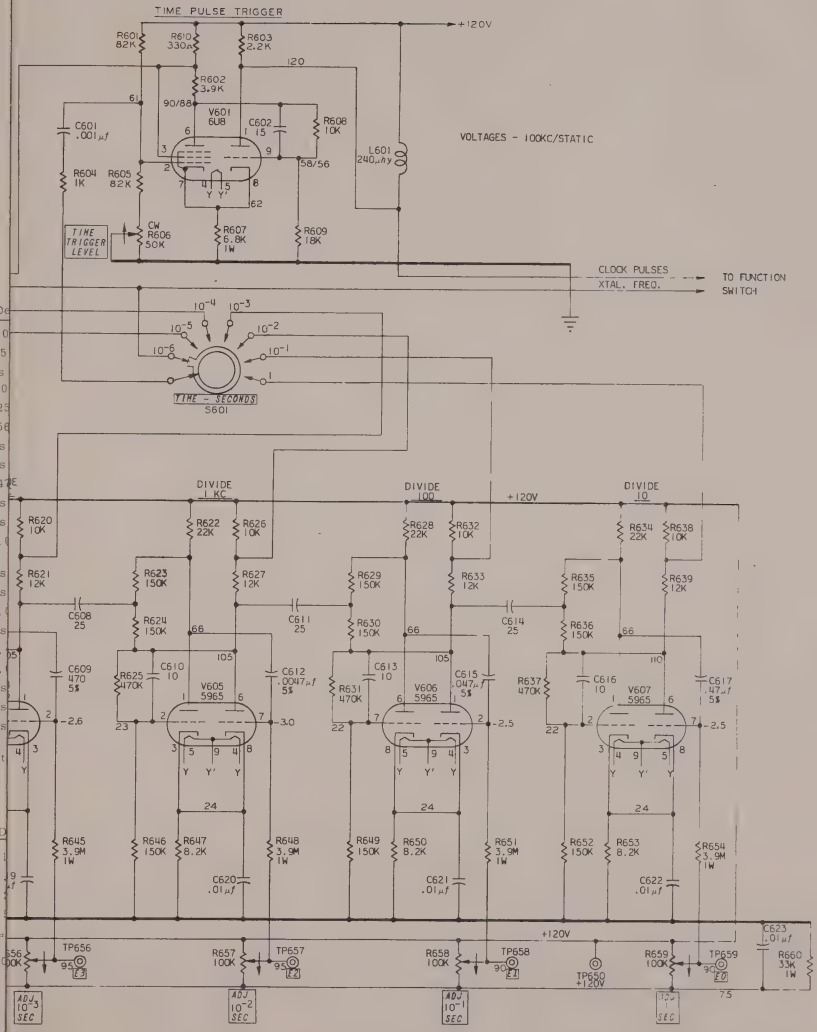
NOTE:

RESISTORS:
- WATTAGE: 1/2W UNLESS OTHERWISE NOTED.
- TOLERANCE: 5% UNLESS OTHERWISE NOTED.

CAPACITORS:
- CAPACITY: IN μμf UNLESS OTHERWISE NOTED.

* VALUE SELECTED FOR INDIVIDUAL INSTRUMENT. SEE TABLE FOR APPROXIMATE RESISTANCE.

SCHEMATIC DIAGRAM
MODELS 7360 & 7350
OSCILLATOR & SHAPER
Dwg. No. 7000C400



Detail No.	Stock No.	
C601	2-3242	Cap., .0
C602	2-2135	Cap., 15
C603		Same as
C604	2-2082	Cap., 10
C605	2-2138	Cap., 25
C606	2-387J	Cap., 56
C607		Same as
C608		Same as
C609	2-3574	Cap., 47
C610		Same as
C611		Same as
C612	2-4206	Cap., , paper
C613		Same as
C614		Same as
C615	2-5603	Cap., ,
C616		Same as
C617	2-5604	Cap., ,
C618	2-2230	Cap., ,
C619		Same as
C620		Same as
C621 to C623		Same as
J601	17-3179	Connect

Detail No.	Stock No.	
C501	2-2082	Cap., 1
C502	2-2230	Cap., , 9
C503	2-2138	Cap., ,
C504	2-3879	Cap., ,
C505		Same a
R514	1-1340	Pot., 1 linear

AS NOTED.
S NOTED.
PT AS NOTED.

Lot 4

SCHEMATIC DIAGRAM
DIVIDER CHAIN
MODEL 7360
Dwg. Nos. 7000B500 & 7000D600

PARTS LIST, DIVIDER CHAIN, MODEL 7360

Refer to Dwg. Nos. 7000B500 & 7000D600

ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin
Cap.	Capacitor
Pot.	Potentiometer
USECO	U.S. Engineering Company, Glendale, California

NOTE: Any resistor which does not appear in the list below is a fixed composition resistor of the value, wattage and tolerance noted on the schematic diagram. All other electrical components are listed.

100KC TO 1CPS DIVIDER CHAIN

		Description	Manufacturer & No.
		Cap., .001 μfd. tubular ceramic	Erie GPK
		Cap., 15 μμfd. Mica	Sangamo RR 1415
		Same as C601	
		Cap., 10 μμfd. Mica	Sangamo RR 1410
		Cap., 25 μμfd. Mica	Sangamo RR 1425
		56 μμfd. 500 V. 5 % ceramic	Vitramor type 70
		Same as C604	
		Same as C605	
		470 μμfd. 500 V. 5 % ceramic	Vitramon type 70
		Same as C604	
		Same as C605	
		.0047 μfd. 5%. subminiature	Sprague 186-P-472-53S3
		Same as C604	
		Same as C605	
		.047 μfd. 5 %. subminiature	Sprague 186-P-473-53S3
		Same as C604	
2-5604		.47 μfd. 5%. subminiature	Sprague 186-P-474-53S3
2-2230		.0 μfd. Disc. ceramic	Erie 811
		Same as C618	
		Same as C619	
		Same as C618	
		Connector BNC	

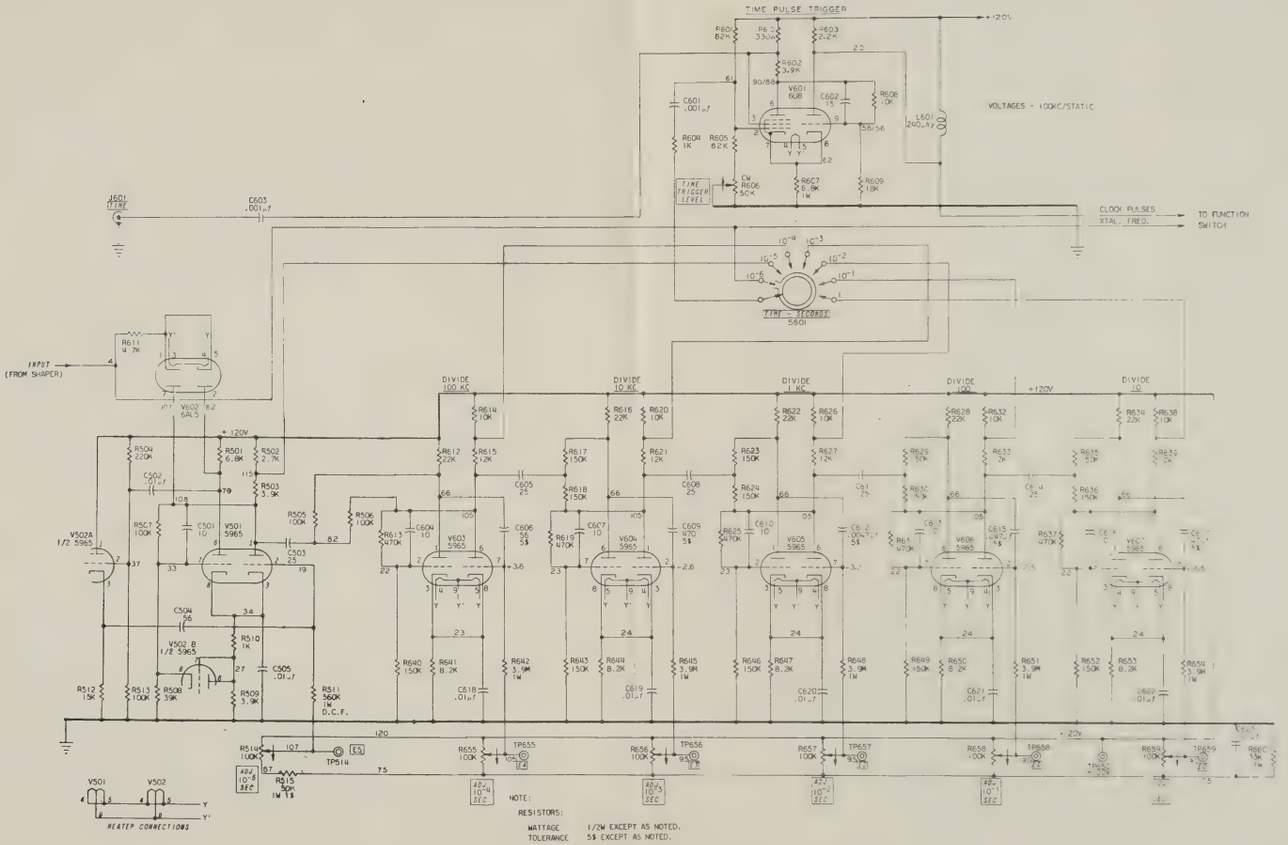
Detail No.	Stock No.	Description	Manufacturer & No.
L601	3-6238	Choke, 240 μHenry Coil	Wilco #3240-15
R642	1-6010	Resistor, 3.9 M, 1 W, 5 % DC	Electra
R648		Same as R642	
R651		Same as R642	
R654		Same as R642	
R655	1-1340	Pot., 100 K	AB JU 1041 DS 3048
R656 to R659		Same as R655	
R660		33 K, 1 W, Deposited Carbon 5%	
S601		Switch, 7 Pos. 1 Pole	
V601		Tube, 6U8	
V602		Tube, 6AL5	
V603 to V607		Tube, 5965	
XV601	4-2973	Socket, 9 Pin W/O Shield W/Lugs	Elco 377 BC
XV602	4-2972	Socket, 7 Pin W/O Shield W/Lugs	Elco 316 BC
XV603 to XV607		Same as XV601	
	17-3294	Tip jack	Johnson 105-602-2
	24-1721	Lock, Shaft	USECO 1510
	24-5789	Shaft, Flexible 4" long	Kupfrian 1598F

1MCS TO 100KCS DIVIDER

		Description	Manufacturer & No.
		Cap., 10 μμfd. Mica, silvered	Sangamo RR 1410
		Cap., .01 μfd. Disc ceramic	Erie 811
		Cap., 25 μμfd. Mica, silvered	Sangamo RR 1425
		Cap., 56 μμfd. 5 %. ceramic	Vitramon Type 10
		Same as C602	
	1-340	Pot., 100 K, 2 W, 10 %, carbon	AB JU 1041 SD 3048

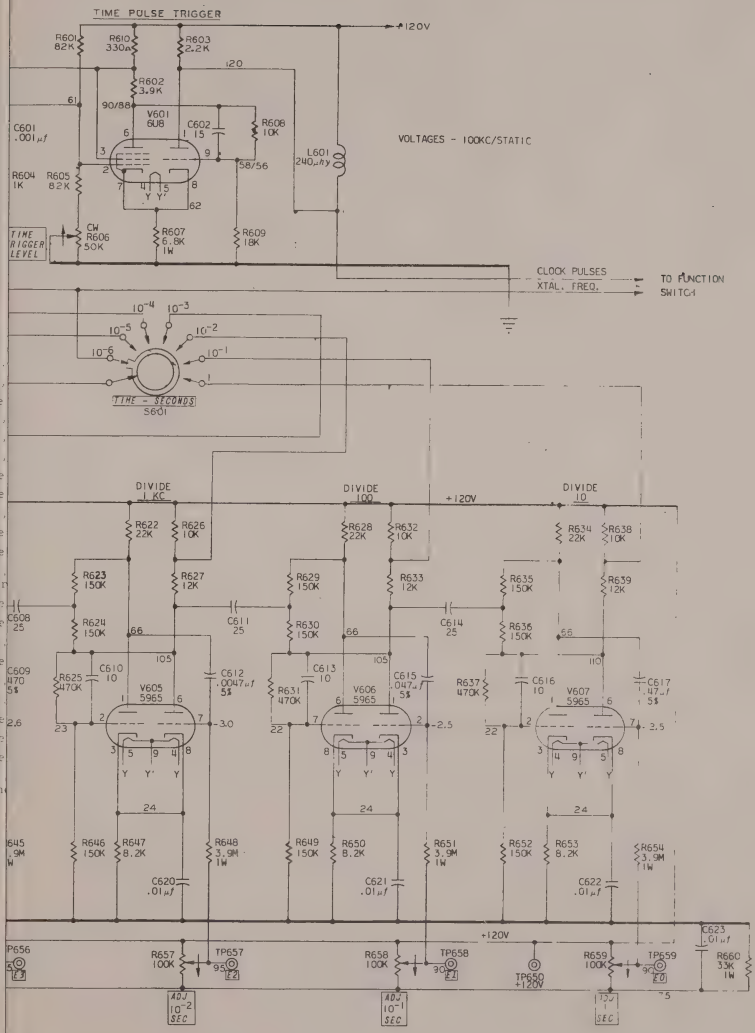
Detail No.	Stock No.	Description	Manufacturer & No.
R	1-6844	Resistor 50 K, 1 W, 5 % deposited carbon	Electra DCF
TP	17-3294	Tip jack, nylon	Johnson 105-602-2
	5-3301	Tube, 5965	
	4-2973	Socket, 9 Pin W/O Shield W/Lugs	Elco 377BC

ADDITIONS



Lot 4

SCHEMATIC DIAGRAM
DIVIDER CHAIN
MODEL 7360
Dwg. Nos. 7000B500 & 7000D600



Detail No.	Stock No.	
C601	2-3242	Cap.
C602	2-2135	Cap.
C603		Same
C604	2-2082	Cap.
C605	2-2138	Cap.
C606	2-3879	Cap.
C607		Same
C608		Same
C609	2-3574	Cap.
C610		Same
C611		Same
C612	2-4206	Cap. paper
C613		Same
C614		Same
C615	2-5603	Cap.
C616		Same
C617	2-5604	Cap.
C618	2-2230	Cap.
C619		Same
C620		Same
C621 to C623		Same
J601	17-3179	Conn

Lot 3

SCHEMATIC DIAGRAM
DIVIDER CHAIN
MODEL 7350
Dwg. No. 7000D600

PARTS LIST, DIVIDER CHAIN, MODEL 7350

Refer to Dwg. No. 7000D600

ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin
Cap.	Capacitor
Pot.	Potentiometer
USECO	U. S. Engineering Company, Glendale, California

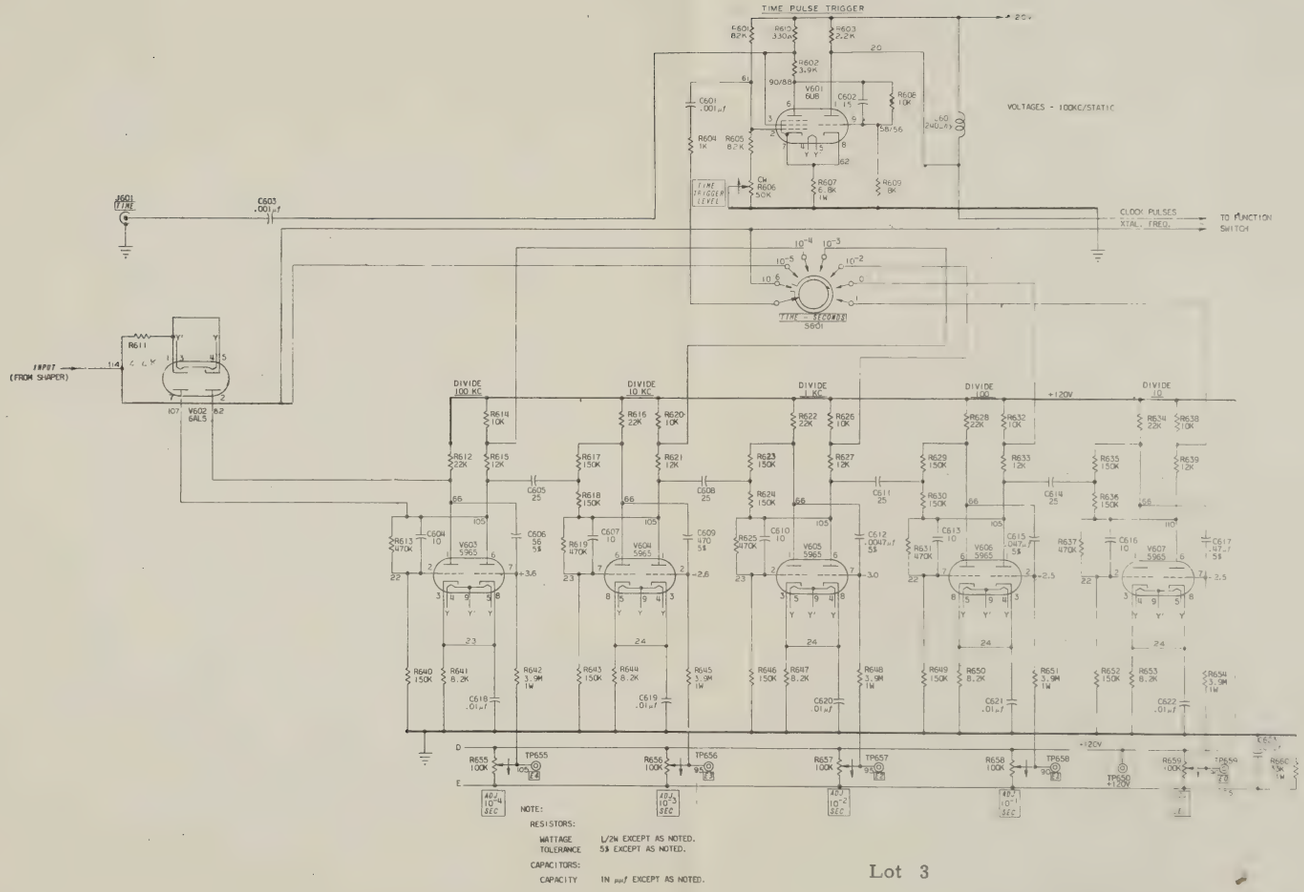
NOTE Any resistor which does not appear in the list below is a fixed composition resistor of the value, wattage and tolerance noted on the schematic diagram. All other electrical components are listed.

100KC TO 1CPS DIVIDER CHAIN

Detail No.	Stock No.	Description	Manufacturer & No.
C601	2-3242	Cap., .001 μfd. tubular ceramic	Erie GPK
C602	2-2135	Cap., 15 μμfd. Mica	Sangamo RR 1415
C603		Same as C601	
C604	[illegible]	Cap., 10 μμfd. Mica	Sangamo RR 1410
C605	[illegible]	Cap., 25 μμfd. Mica	Sangamo RR 1425
C606	[illegible]	Cap., 56 μμfd. 500 V. 5 % ceramic	Vitramor type 70
C607		Same as C604	
C608		Same as C605	
C609	[illegible]	Cap., 470 μμfd. 500 V. 5 % ceramic	Vitramon type 70
C610		Same as C604	
C611		Same as C605	
C612	2-4206	Cap., .0047 μfd. 5%, subminiature paper	Sprague 186-P-472-53S3
C613		Same as C604	
C614		Same as C605	
C615	2-5603	Cap., .047 μfd. 5 %, subminiature	Sprague 186-P-473-53S3
C616		Same as C604	
C617	2-5604	Cap., .47 μfd. 5%, subminiature	Sprague 186-P-474-53S3
C618	2-2230	Cap., .01 μfd. Disc. ceramic	Erie 811
C619		Same as C618	
C620		Same as C619	
C621 to C623		Same as C618	
J601	17-3179	Connector BNC	

Detail No.	Stock No.	Description	Manufacturer & No.
L601	3-6238	Choke, 240 μHenry Coil	Wilco #3240-15
R642	1-6010	Resistor, 3.9 M, 1 W, 5 % DC	Electra
R648		Same as R642	
R651		Same as R642	
R654		Same as R642	
R655	1-1340	Pot., 100 K	AB JU 1041 DS 3048
R656 to R659		Same as R655	
R660	1-4509	33 K, 1 W, Deposited Carbon 5%	
S601	12-5700	Switch, 7 Pos, 1 Pole	
V601	5-2526	Tube, 6U8	
V602	5-0978	Tube, 6AL5	
V603 to V607	5-3301	Tube, 5965	
XV601	4-2973	Socket, 9 Pin W/O Shield W/Lugs	Elco 377 BC
XV602	4-2972	Socket, 7 Pin W/O Shield W/Lugs	Elco 316 BC
XV603 to XV607		Same as XV601	
	17-3294	Tip jack	Johnson 105-602-2
	24-1721	Lock, Shaft	USECO 1510
	24-3788	Shaft, Flexible 4" long	Kupfrian 1598F

ADDITIONS

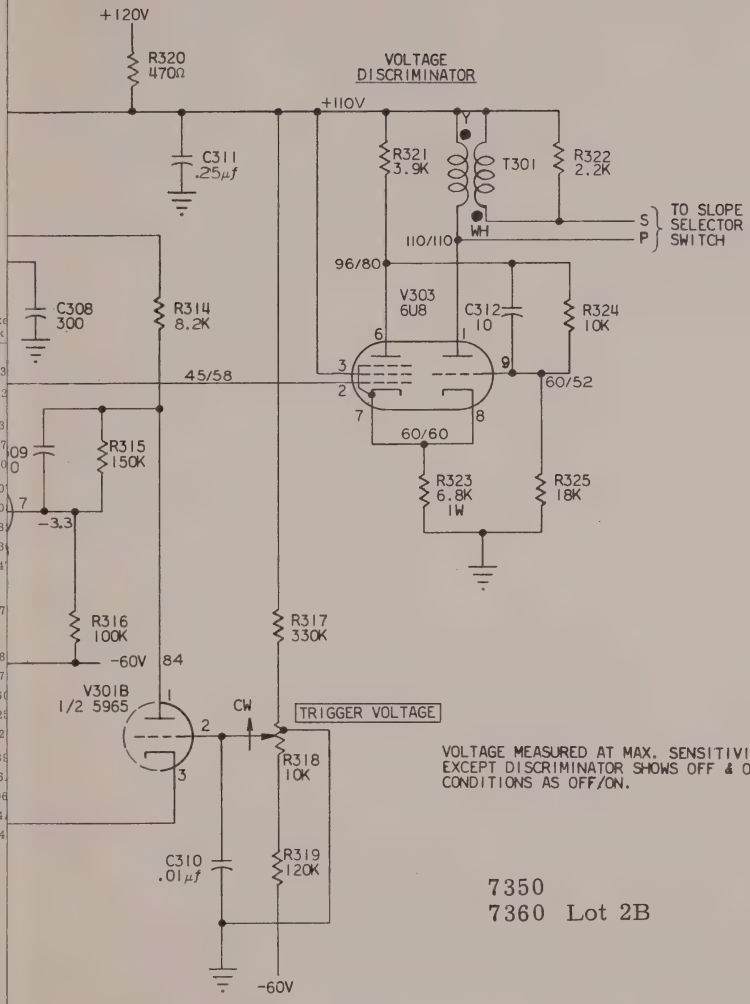


Lot 3

SCHEMATIC DIAGRAM
DIVIDER CHAIN
MODEL 7350
Dwg. No. 7000D600

AB
BDB
Cap.
CT
CH
DC
DCU
FC
GE
Gen. Ind.
HV
IPC

Detail No.	Berke Stock
C301	2-223
C302 & C303	2-232
C304	2-193
C305	2-647
C306	2-260
C307	2-260
C308	2-260
C309	2-208
C310	2-223
C311	2-574
C312	
J301 & J302	17-317
R301	1-118
R302	1-557
R303	1-0960
R304	1-0225
R305	1-1182
R306	1-2489
R307	1-1166
R308	1-2396
R309	1-1164
R310	1-1174



VOLTAGE MEASURED AT MAX. SENSITIVITY, EXCEPT DISCRIMINATOR SHOWS OFF & ON CONDITIONS AS OFF/ON.

7350
7360 Lot 2B

TE:

RESISTORS:

WATTAGE 1/2W UNLESS NOTED OTHERWISE.
TOLERANCE 5% UNLESS NOTED OTHERWISE.

CAPACITORS:

CAPACITY IN μμf UNLESS NOTED OTHERWISE.
VOLTAGE RATING

SCHEMATIC DIAGRAM
INPUT TRIGGER CHANNEL
MODELS 7360 & 7350
Dwg. No. 7000C300

PARTS LIST, "A" & "B" INPUT CHANNEL MODELS 7350 & 7360

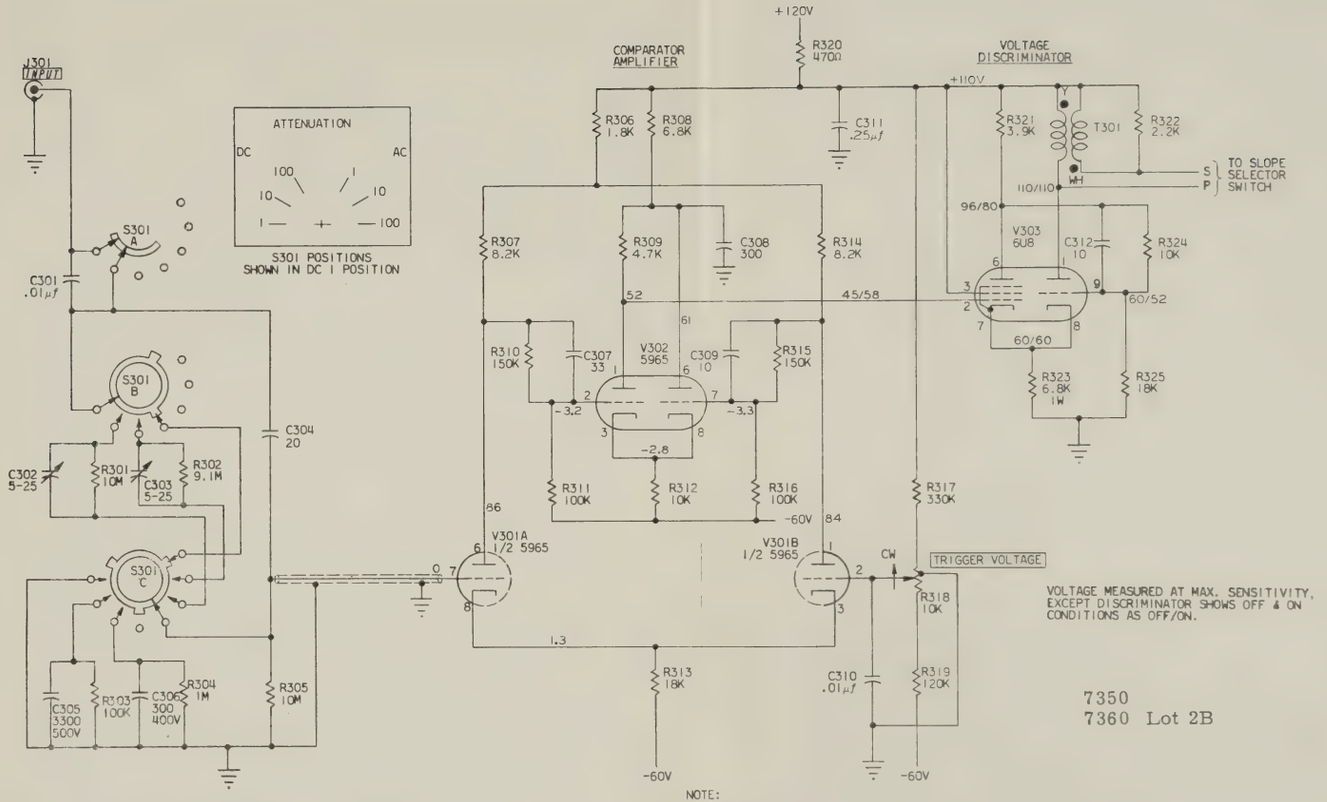
Refer to Dwg. No. 7000C300

ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin	LV	Low Voltage
BDB	Berkeley Division Beckman, Richmond, Calif.	μa	Microamps
Cap.	Capacitor	μh	Microhenries
CT	Center Tap	ma	Milliamps
CH	Cutler-Hammer Co., Milwaukee, Wisconsin	mh	Millihenries
DC	Deposited Carbon	Pot.	Potentiometer
DCU	Decimal Counting Unit	RCA	Radio Corporation of America, Harrison, New Jersey
FC	Fixed Composition	RES.	Resistor
GE	General Electric, Schenectady, New York	USECO	U.S. Engineering Company, Glendale, California
Gen. Ind.	General Industries, Elyria, Ohio	VDC	Volts Direct Current
HV	High Voltage	WW	Wire Wound
IPC	Industrial Products Co., Danbury, Connecticut		

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C301	2-2230	Cap., .01 μfd, ceramic disc	Erie 811
C302 & C303	2-2326	Capacitor, 5-25 μμfd, Variable	Erie 557-5
C304	2-1939	Capacitor, 20 μμfd, Mica	Sangamo RR 1420
C305	2-6474	Capacitor, 3300 μμfd, Mica	Sangamo CR 1233
C306	2-2608	Capacitor, 300 μμfd, Mica	Sangamo RR 1330
C307	2-2607	Cap., 33 μμfd, Mica	Sangamo RR 1433
C308	2-2608	Cap., 300 μμfd, Mica	Sangamo RR 1330
C309	2-2082	Cap., 10 μμfd, Mica	Sangamo RR 1410
C310	2-2230	Cap., .01 μfd, Disc	Erie 811
C311	2-5747	Cap., .25 Mfd, 200 V Metalized	Hopkins Eng.
C312		Same as C309	
J301 & J302	17-3179	Connector, Low Voltage	IPC MS 595
R301	1-1182	Resistor, 10 M, 1/2 W, 5 %	AB EB 1065
R302	1-5572	Resistor, 9.1 M, 1/2 W, 5 %	AB EB 9155
R303	1-0960	Resistor, 100 K, 1/2 W, 5 %	AB EB 1045
R304	1-0225A	Resistor, 1 M, 1/2 W, 5 %	AB EB 1055
R305	1-1182	Resistor, 10 Meg, 1/2 W 5%	AB EB 1065
R306	1-2489	Res., 1.8 K, 1/2 W, 5 %	AB EB 1825
R307	1-1166A	Res., 8.2 K, 1/2 W, 5 %	AB EB 8225
R308	1-2396	Res., 6.8 K, 1/2 W, 5 %	AB EB 6825
R309	1-1164A	Res., 4.7 K, 1/2 W, 5 %	AB EB 4725
R310	1-1174A	Res., 150 K, 1/2 W, 5 %	AB EB 1545
R311	1-0960	Res., 100 K, 1/2 W, 5 %	AB EB 1045
R312	1-0210A	Res., 10 K, 1/2 W, 5 %	AB EB 1035
R313	1-1169A	Res., 18 K, 1/2 W, 5 %	AB EB 1835
R314		Same as R307	
R315		Same as R310	
R316		Same as R311	
R317	1-1212	Res., 330 K, 1/2 W, 5 %	AB EB 3345
R318	1-5573	Potentiometer, 10 K, Tapped	AB JU 1031
R319	1-1095	Res., 120 K, 1/2 W, 5 %	AB EB 1245
R320	1-3210	Res., 470 Ω, 1/2 W, 5 %	AB EB 4715
R321	1-3609	Res., 3.9 K, 1/2 W, 5 %	AB EB 3925
R322	1-5598	Res., 2.2 K, 1/2 W, 5 %	AB EB 2225
R323	1-5079	Res., 6.8 K, 1 W, 5 %	AB EB 6821
R324		Same as R312	
R325	1-1169A	Res., 18 K, 1/2 W, 5 %	AB EB 1835
R326	1-0225A	Res., 1M, 1/2 W, 5 % fixed composition	
S301	12-5698	Switch, 2 Sec., 7 Pos.	
T301	6-5821	Transformer, Pulse 300 μ H	Pulse Eng.
V301 & V302	5-3301	Tube, 5965	RCA
V303	5-2526	Tube, 6U8	GE
XV301, XV302 & XV303	4-2973	Socket, 9 Pin W/O Shield W/ Lugs	Elco 377BC
	10-2013	Wire RG-62/U	Belden

ADDITIONS



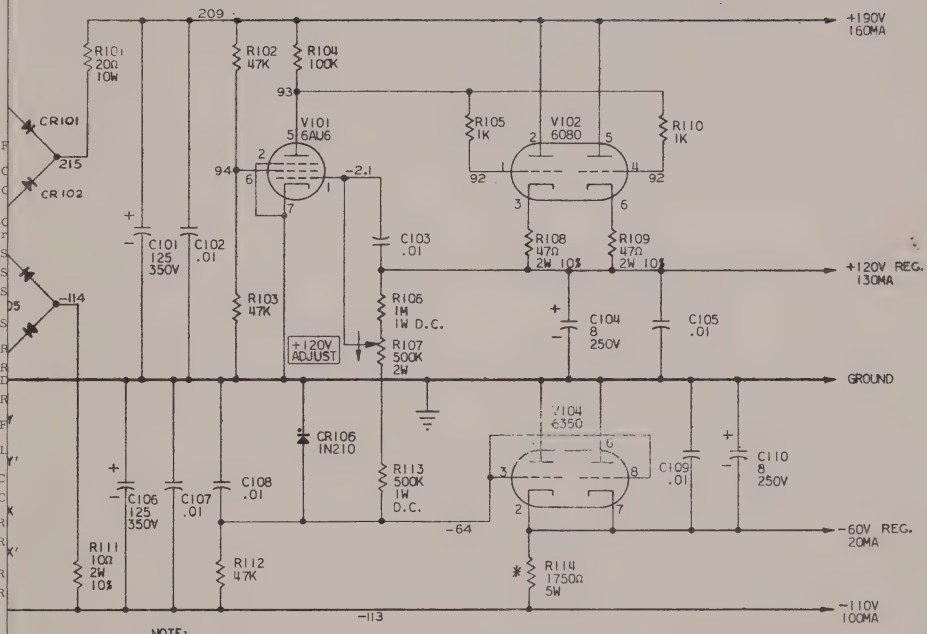
VOLTAGE MEASURED AT MAX. SENSITIVITY, EXCEPT DISCRIMINATOR SHOWS OFF & ON CONDITIONS AS OFF/ON.

7350
7360 Lot 2B

SCHEMATIC DIAGRAM
INPUT TRIGGER CHANNEL
MODELS 7360 & 7350
Dwg. No. 7000C300

AB
BDB
Cap.
CT
CH
DC
DCU
FC
GE
Gen. Ind.
HV
IPC

Detail No.	Berkeley Stock No.	
B101	9-3389	F
C101	2-4254	C
C102 & C103	2-2330	C
C104	2-3982	C
C105		S
C106		S
C107, C108 C109		S
C110		S
CR101	8-5631	R
CR105	8-856[illegible]	R
CR106		R
F101 & F1[illegible]		F
J101	21-1677	L
J101	17-1635	C
J102	17-3185	C
R101	1-2927	R
R102 & R103	1-0214	R
R104	1-0960	R
R105	1-0209A	R



NOTE:

(1)-RESISTORS:

WATTAGE ——— 1/2W UNLESS OTHERWISE NOTED.
TOLERANCE ——— 5% UNLESS OTHERWISE NOTED.

(2)-CAPACITORS:

CAPACITY ——— IN μf UNLESS OTHERWISE NOTED.

(3)-*R114 1250Ω FOR 7050, 7060 AND 7060A.

7350 Lot 13
7360 Lot 15

Y
Y'
ONS

7260	7160	7350	7250	7150
4A	4A	3A	3A	3A
4A	4A	3A	3A	3A
NONE	NONE	NONE	NONE	NONE

SCHEMATIC DIAGRAM
MODELS 7360 & 7350
POWER SUPPLY
Dwg. No. 7000C100

PARTS LIST, MODELS 7350 & 7360 POWER SUPPLY

Refer to Dwg. No. 7000C100

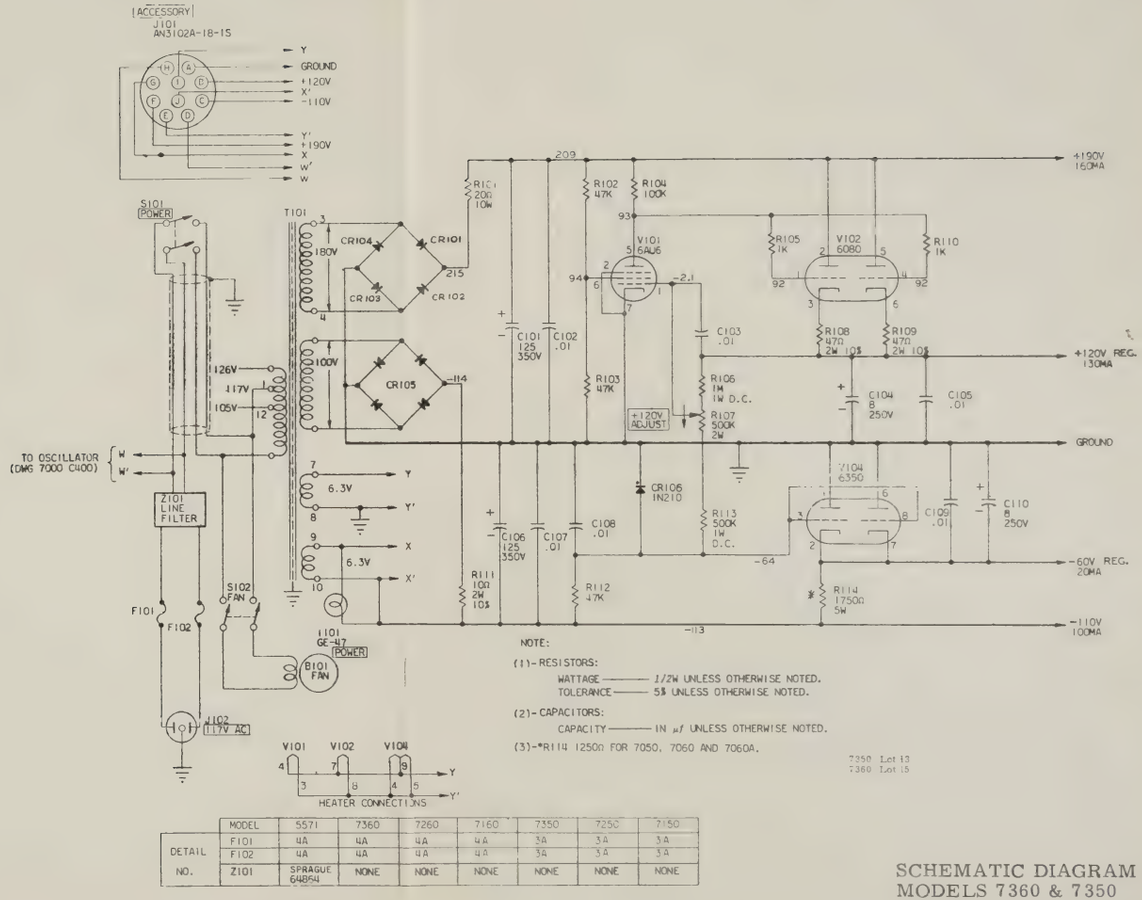
ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin		
BDB	Berkeley Division Beckman, Richmond, Calif.	LV	Low Voltage
Cap.	Capacitor	μa	Microamps
CT	Center Tap	μh	Microhenries
CH	Cutler-Hammer Co., Milwaukee, Wisconsin	ma	Milliamps
DC	Deposited Carbon	mh	Millihenries
DCU	Decimal Counting Unit	Pot.	Potentiometer
FC	Fixed Composition	RCA	Radio Corporation of America, Harrison, New Jersey
GE	General Electric, Schenectady, New York	Res.	Resistor
Gen. Ind.	General Industries, Elyria, Ohio	USECO	U.S. Engineering Company, Glendale, California
HV	High Voltage	VDC	Volts Direct Current
IPC	Industrial Products Co., Danbury, Connecticut	WW	Wire Wound

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
B101	9-3389	Fan Motor	General Industries A8CW
C101	2-4254	Capacitor, 125 μfd, 350 V	Mallory FP 140
C102 & C103	2-2330	Capacitor, .01 μfd, Disc.	Erie Type 811
C104	2-3982	Capacitor, 8 μfd, 250 V Elect-	Sangamo MT 2508
C105		Same as C102	
C106		Same as C101	
C107, C108 C109		Same as C102	
C110		Same as C104	
CR101	9-5632	Rectifier	GE 6RS22PB5AA1
CR105	9-5561	Rectifier, 110 V, RMS, 110V, DC 130 MA	GE 6RS21PB3AT1
CR106		Rectifier, 1N210 as per spec.	National Semi-Cond.
F101 & F102		Fuse, 3 Amp, Slo Blo	
I101	34-1827	Lamp	GE 47
J101	17-1635	Connector, AN 3102A-18-1S	Cannon
J102	17-3185	Connector, #7486	Hubbell
R101	1-2927	Res., 20 ohms, 10 W	Tru-Ohm FRL 10
R102 & R105	1-0214	Res., 47 K, 1/2 W, 5 %	AB EB 4735
R104	1-0960	Res., 100 K, 1/2 W, 5 %	AB EB 1045
R106	1-0209A	Res., 1K, 1/2 W, 5 %	AB EB 1025

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
R106	1-0257	Res., 1 M, 1 W, 5 % DCF	Stemag Type A2
R107	1-2905	Pot., 500 K, 2 W	AB JU 5041
R108 & R109	1-2961	Res. 47 ohms, 2 W, 10 %	AB HB 4701
R110		Same as R105	
R111	1-5628	Res., 10 ohms, 2 W, 10 %	AB HB 1001
R112		Same as R102	
R113	1-6258	Res., 500 K, 1 W, 5 %, DCF	Stemag Type A2
R114	1-6237	Res., 1750 ohms, 5 W Power W.W.	Tru-Ohm FRL 5
S101	12-1642	Switch, DPST Bat Toggle	CH 8370 K8
S102	12-3851	Switch, DPST	CH 8270K7
T101	6-6333	Transformer, Power as per spec. dwg.	Electro
V101	5-0550	Tube, 6AU6	RCA
V102	5-2625	Tube, 6080	RCA
V104	5-5631	Tube, 6350	RCA
XF101 & XF102	4-3154	Fuse Post,	Bussman HKP
XI101	4-1678	Lamp Socket, Green Faceted	Dialco 81410-132
XV101	4-2972	Socket, 7 Pin	Elco 316 BC
XV102	4-2377	Socket, Octal	Cinch 9950
XV104	4-2973	Socket, 9 Pin	Elco 377 BC
	10-0407	Cable 8424	
	10-6506	Cord Set, End Hubbell #7484 18/3 SJ6' one end model #73 other	Corrish
	24-2707	Clamp, AN 3057-10A	Cannon
	24-5799	Fan Blade, 5 1/2"	Torrington

ADDITIONS



DETAIL NO.	MODEL	5571	7360	7260	7160	7350	7250	7150
	F101	4A	4A	4A	4A	3A	3A	3A
	F102	4A	4A	4A	4A	3A	3A	3A
	Z101	SPRAGUE 6A864	NONE	NONE	NONE	NONE	NONE	NONE

SCHEMATIC DIAGRAM
MODELS 7360 & 7350
POWER SUPPLY
Dwg. No. 7000C100

INSTRUCTION MANUAL

Models 705AH, 705AJ & 705AK
DECIMAL COUNTING UNITS

Lot No.

BERKELEY division
Beckman Instruments, Inc.

Richmond 4, California
18 March 1957

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.

(b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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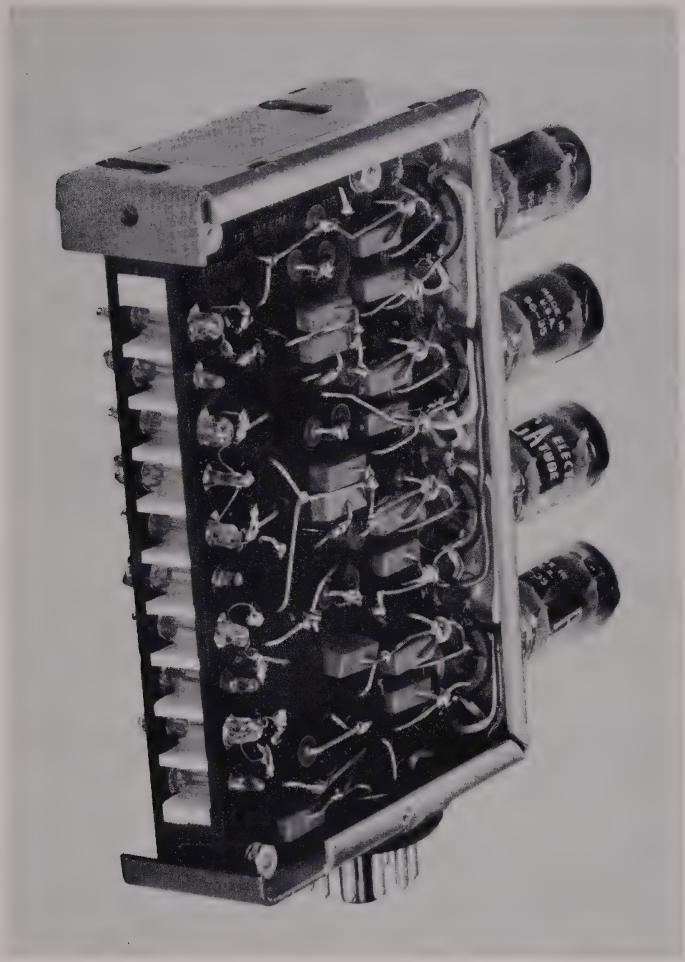

Model 705AH Decimal Counting Unit with side covers and indicating panel removed.

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INTRODUCTION

These decimal counting units are direct-reading, plug-in electronic counters. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99, 999 resetting to "00, 000" on the 100, 000th pulse.

Models 705AH and 705AK generate a binary coded decimal readout. This code is in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Direct reading, decimal presentation

Power Requirements

Heaters: 6.3 v. at 1.2 amps

Plates: 300 v. at 13 ma

Input Requirements

Negative pulses (See "OPERATION")

Output Characteristics -

Designed to drive a Model 705A DCU or any modification thereof (i.e., 705AH, 705AK, etc.)

Resolution of Paired Pulses

5 microseconds

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate

100, 000 counts per second

Construction

Plug-in unit, 11-pin socket

OPERATION

Power Requirements. The heaters require 6.3 volts ac at 1.2 amperes. The plate circuits may be operated on from 200 to 400 volts, although the design center is 300 volts at 13 ma. Plate voltage may be applied in the form of B + and B - voltages. The d-c level of all output voltages will depend upon the level of the plate supply voltages.

Input Requirements. A negative pulse at least two microseconds wide is required to drive the unit. The optimum pulse amplitude depends on the rise time. With a rise time of 0.5 microseconds (measured between ten and ninety percent values) the pulse amplitude should be between 75 and 135 volts. With a two-microsecond rise time, the amplitude should be between 120 and 165 volts. When operating the plate circuits on 300 volts, optimum performance is obtained with a rise time of one microsecond or less and a pulse amplitude of 100 volts. If the unit is powered by unregulated d-c supplies, the input pulse amplitude should vary in phase with the supply voltage. The input load presented when an input pulse occurs is 15K ohms in series with 100 micromicrofarads.

Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from + 135 to + 55 volts with respect to B-. This transient can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected

between the output terminal and ground must not be less than 300K or 6K in series with 100 micro-microfarads.

Method of Resetting after a Counting Period. A DCU can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity to the proper pin of the DCU plug. See the table below.

	RESET TO ZERO		RESET TO NINE	
	Pulse Polarity	Applied at Pin No.	Pulse Polarity	Applied at Pin No.
705AH	Neg.	8	Pos.	8
705AJ	Neg.	8	Pos.	8
	Pos.	3	Neg.	3
705AK	Neg.	8	Pos.	8

The reset pin (or pins in the base of Model 705AJ) should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3μseconds wide is adequate. A 100-volt pulse need be only 1.5μseconds wide. There is no maximum pulse width; however the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting a reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

Binary Code Readout. Models 705AH and 705AK generate a modified binary code representing the decimal digit registered. The code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor except in the case of pin 4 on the 705AK DCU. This pin is connected directly to a plate of the fourth binary. To obtain a readout voltage at this pin, it is necessary to add a 1.2M resistor externally.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage (Pin 2 of DCU plug)	2nd Binary Stage (pin 6 of DCU plug)	3rd Binary Stage (Pin 9 of DCU plug)	4th Binary (Pin 10, 705AH) (Pin 4, 705AK)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps During the Counting Period. On Models 705AJ and 705AK, it is possible to prevent the neon bulbs from lighting by placing approximately -100 volts with respect to B- on pin 10 of the DCU plug. Ordinarily, the user will wish to extinguish the bulb while the DCU is actively counting, and to allow them to light, indicating the registered count at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut

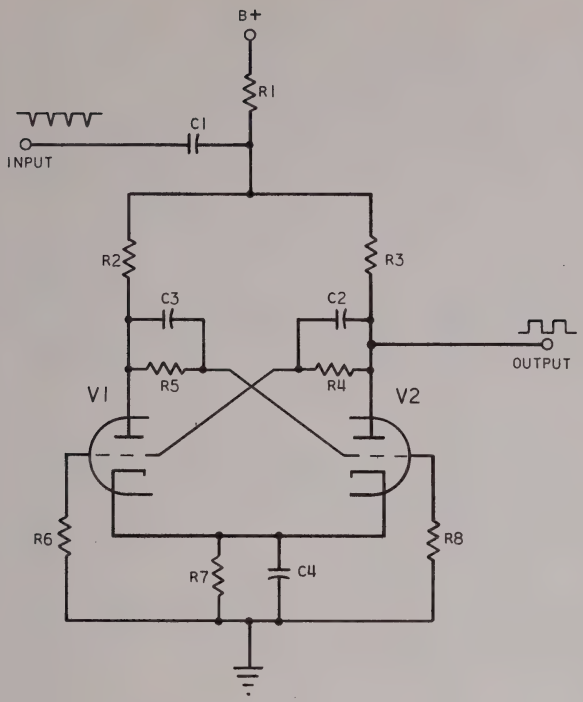


FIGURE 1. A TYPICAL BINARY.

off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B- voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

The Scale of Ten. In the Model 705A four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two positive feedback paths. (See Figures 2 and 3). For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now

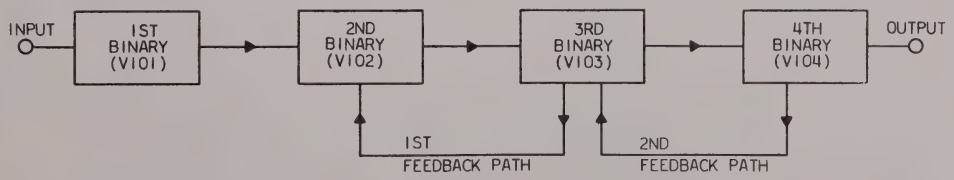


FIGURE 2. BLOCK DIAGRAM.

corresponds to a binary count of six. The sixth input pulse (equivalent to the eighth in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

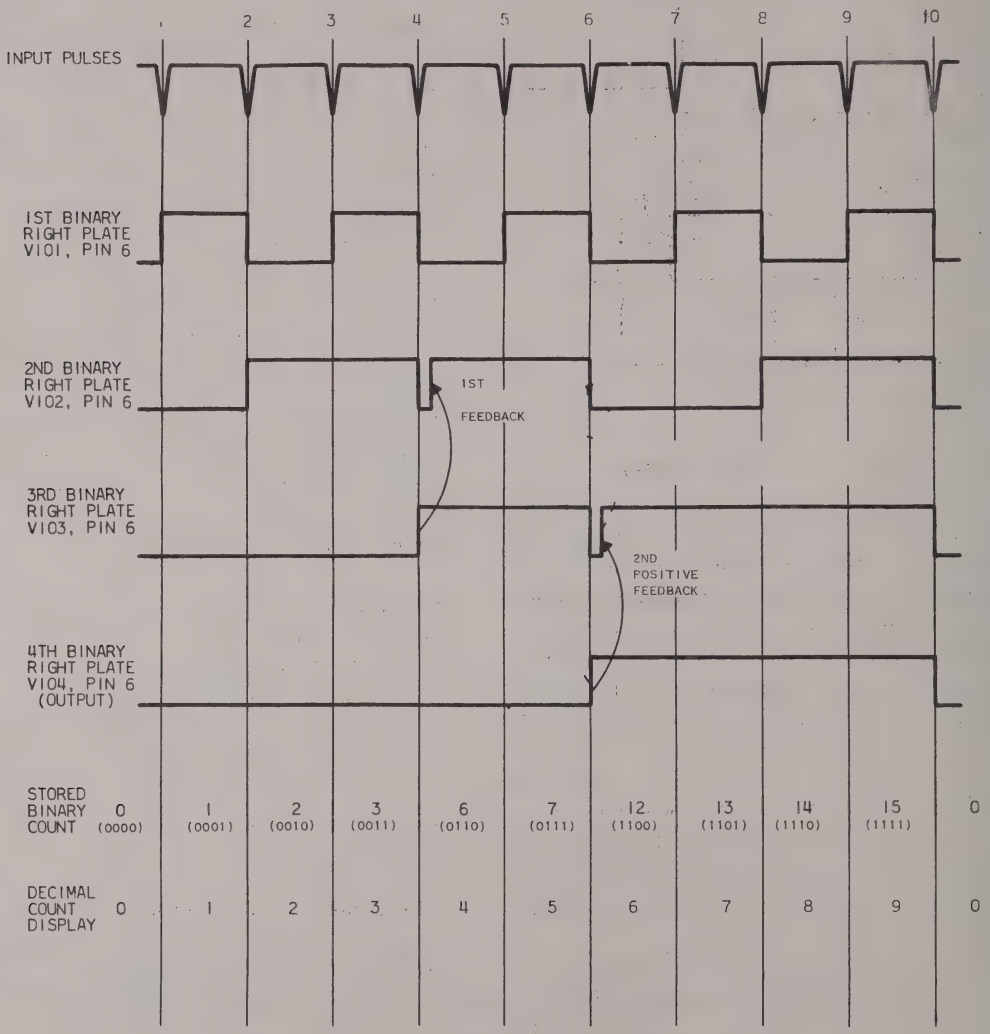


FIGURE 3. IDEALIZED WAVEFORMS. "RIGHT PLATE" REFERS TO THE PLATE APPEARING ON THE RIGHT-HAND SIDE OF THE BINARY AS DRAWN ON THE SCHEMATIC.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4 & 5.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissable tolerances.

TROUBLESHOOTING CHART

NOTE: Reset unit to zero before testing for symptoms

SYMPTOMS	POSSIBLE CAUSES
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Extraneous input signals. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Units Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.

Units counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.

1.	Units skips every other number	(a) First stage defective. (b) Input circuit supplies double pulses.
2.	Two stable states per cycle.	(a) Second stage defective (Display sequence may be 01 or 45). (b) Loss of drive to second stage (01).
3.	Four stable states per cycle.	(a) Third stage defective (Display sequence may be 0123 or 6789). (b) Loss of drive to third stage (0123).
4.	Six stable states per cycle.	(a) Output excessively loaded (Display sequence may be 012345). (b) Last stage inoperative (Display sequence may be 012345 or $67^{89}_{23}89$*). (c) Loss of drive to fourth stage (Display sequence may be 012345).
5.	Eight stable states per cycle or any failure where two successive numbers are skipped.	(a) Second or third stage failure.
6.	Ten stable states per cycle, but the lighting sequence is incorrect.	(a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.
7.	Twelve stable states per cycle.	(a) When lighting sequence is $0123^{01}_{45}456789$* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary. (b) When the lighting sequence is $01234567^{23}_{89}89$ the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

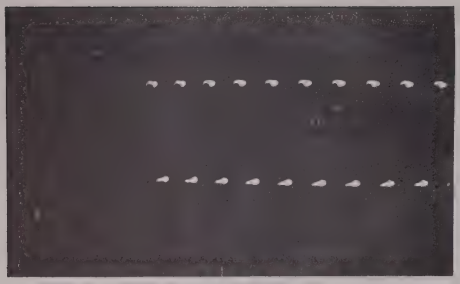
* One digit above another means both lamps are lit.

TABLE OF VOLTAGES & RESISTANCES

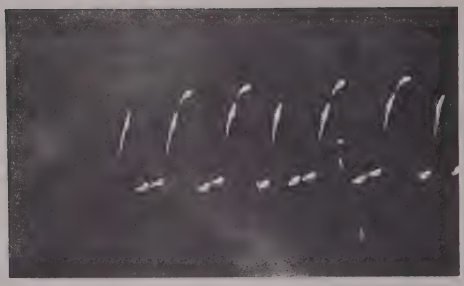
Tube	Pin No.	D-C Voltage with respect to B-.*	Resistance to B minus Terminal**
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

* Voltages measured in unit with 300-volt plate supply

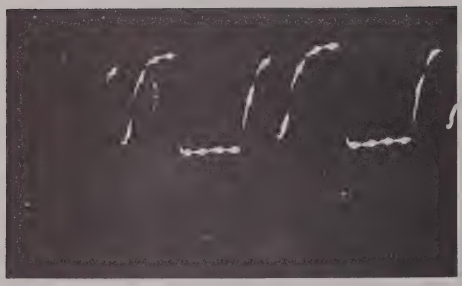
** Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



(1) First Binary Output (V101, Pin 6).
Upper voltage level is +168v
Lower voltage level is +55v



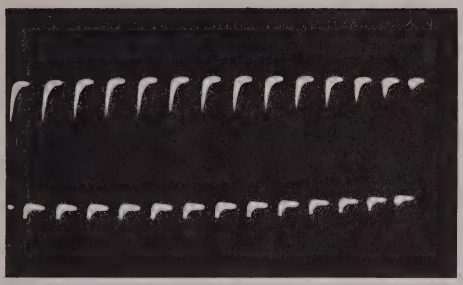
(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v.

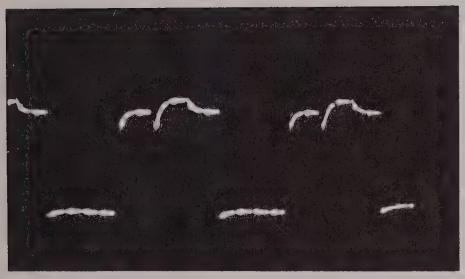
(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 4. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 20KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.

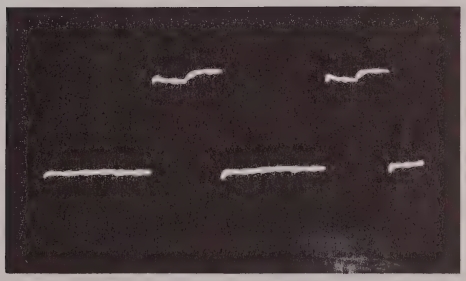


(1) First Binary Output (V101, Pin 6).
Upper Voltage level is +168V
Lower voltage level is +55v

(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v



(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 5. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 100KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.

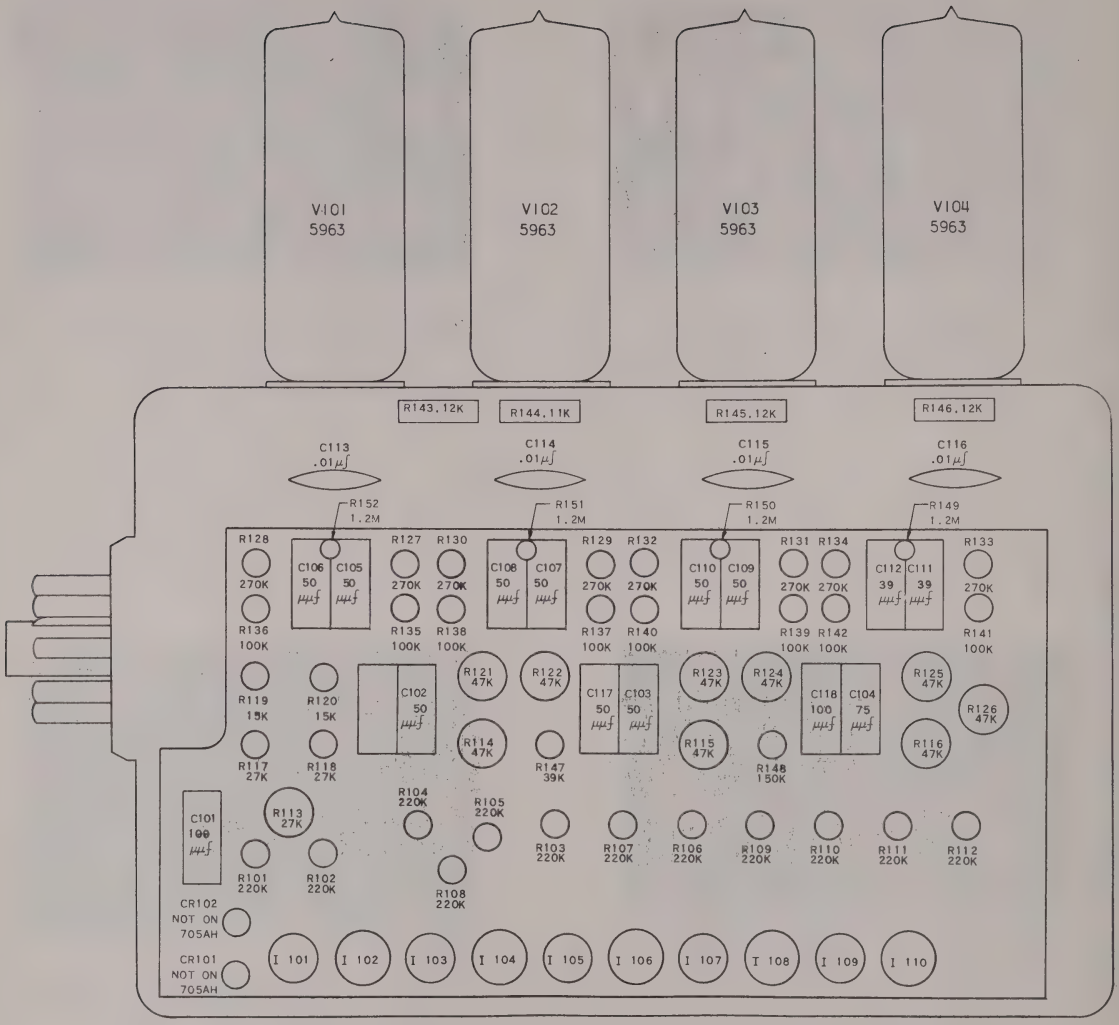
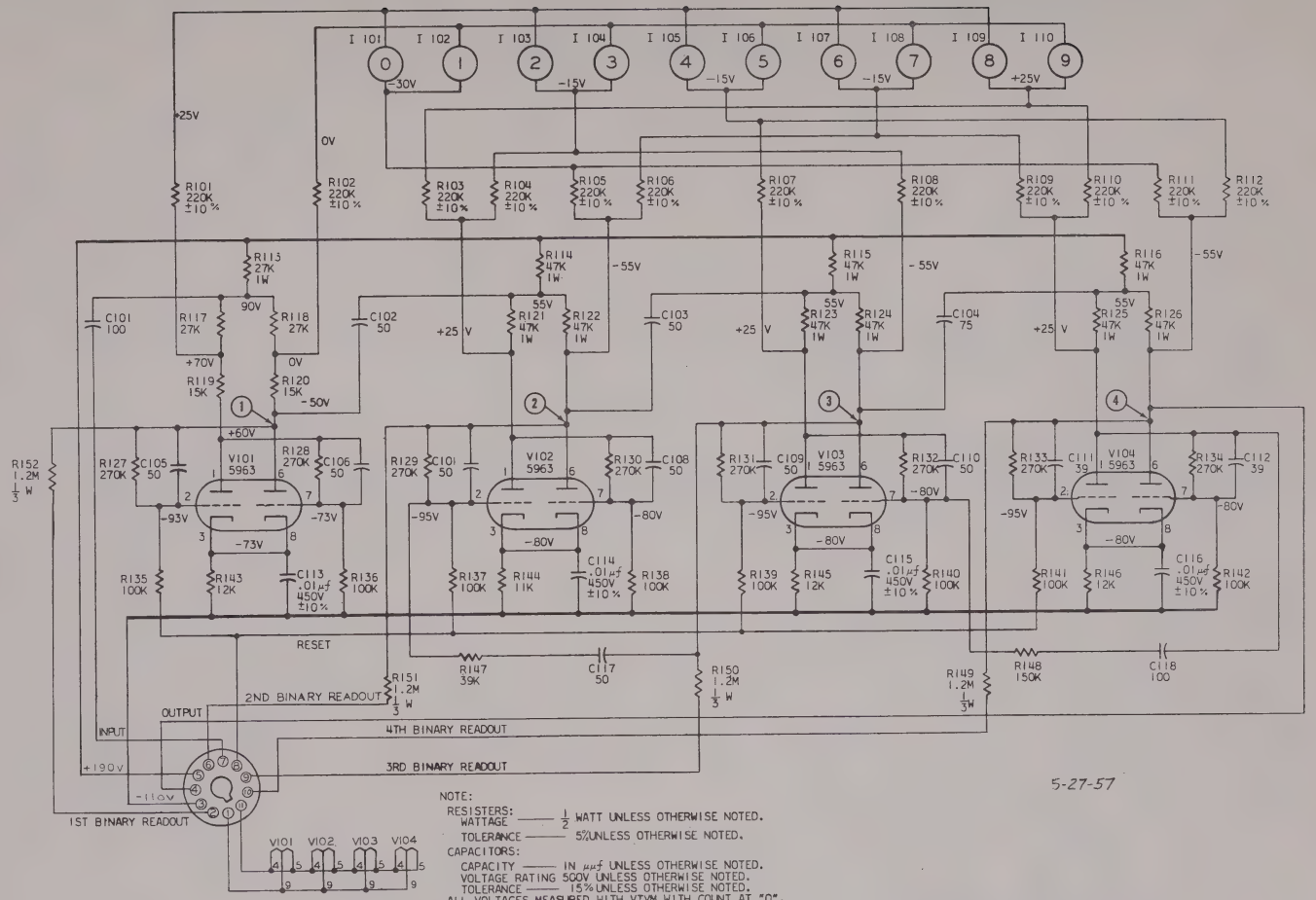
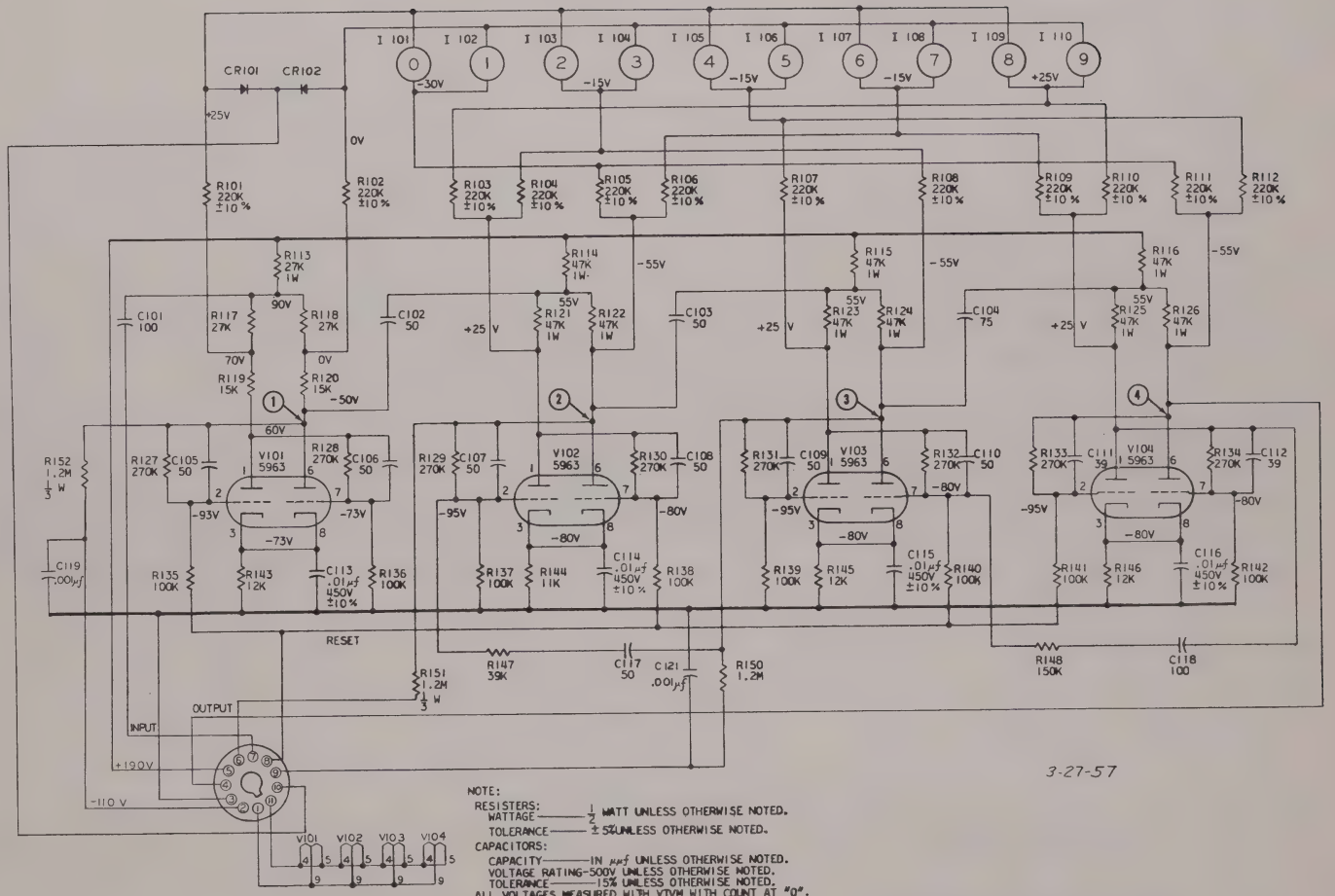


FIGURE 6. PARTS LOCATION



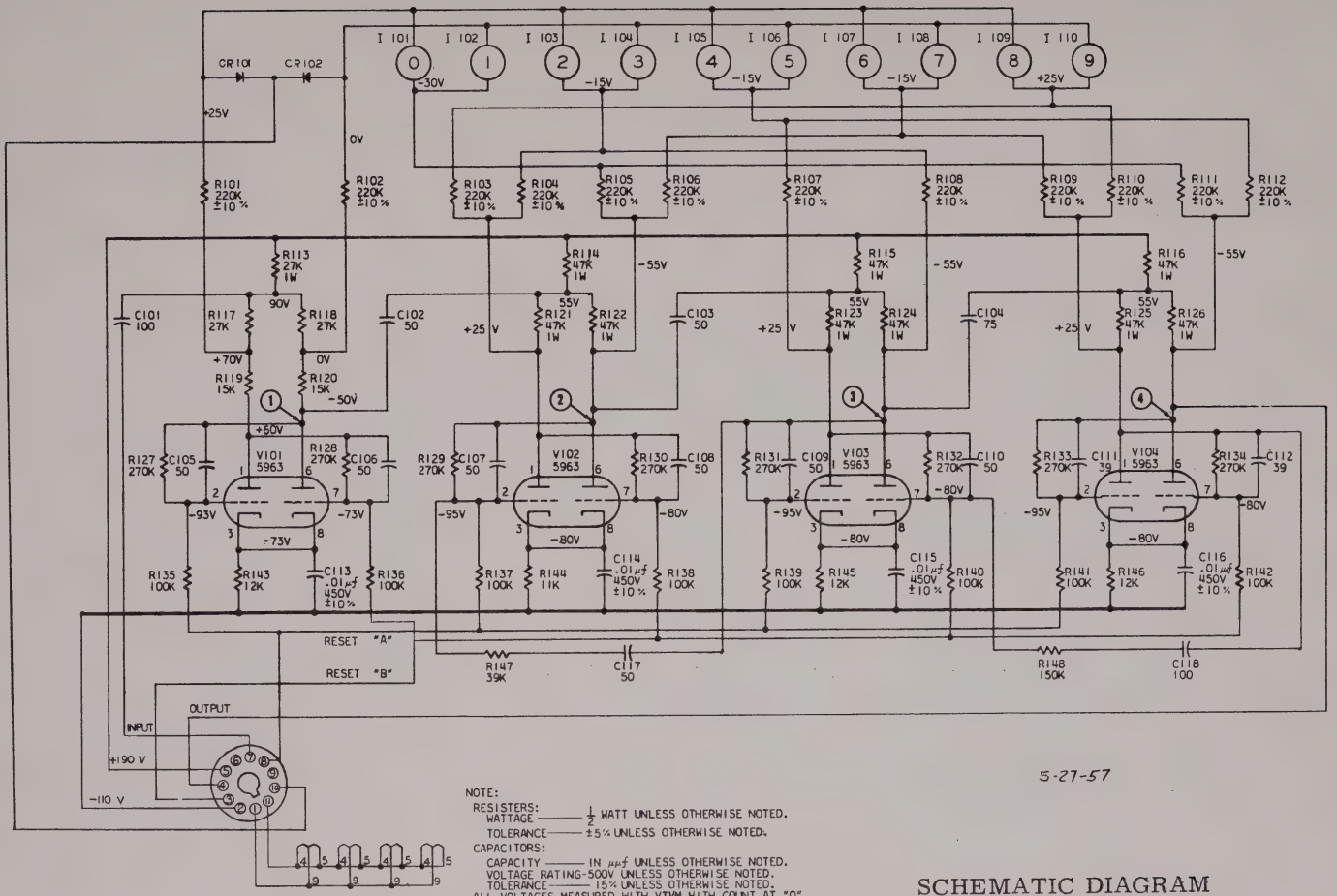
SCHEMATIC DIAGRAM
MODEL 705AH
DECIMAL COUNTING UNIT



3-27-57

NOTE:
RESISTERS:
WATTAGE——$\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE——±5%UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY——IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE——15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".

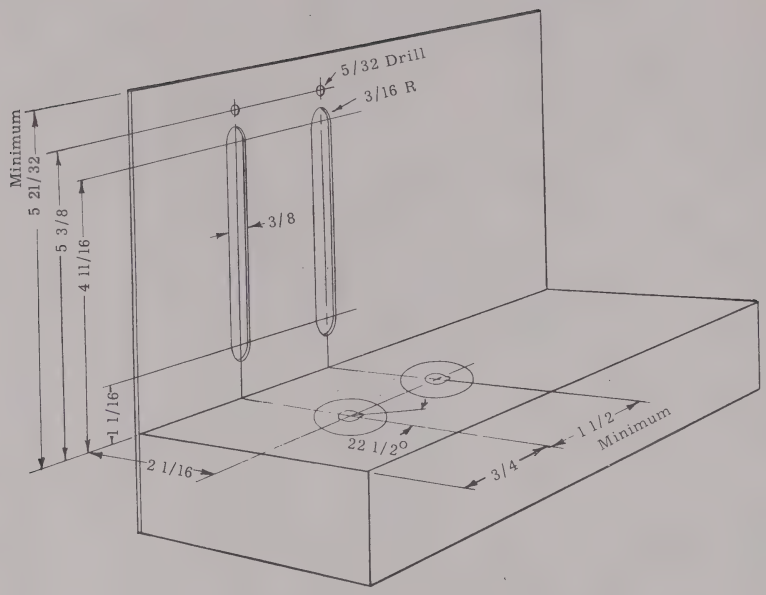
SCHEMATIC DIAGRAM
MODEL 705AK
DECIMAL COUNTING UNIT



5-27-57

NOTE:
RESISTERS:
WATTAGE ——— ½ WATT UNLESS OTHERWISE NOTED.
TOLERANCE——— ±5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY ——— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE——— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".
AND PIN #10 DISCONNECTED.

SCHEMATIC DIAGRAM
MODEL 705AJ
DECIMAL COUNTING UNIT



NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

The drawing shows chassis dimensions for mounting two Model 705A DCU's side by side. All modifications of the Model 705A (705AH, 705AF, etc.) have precisely the same dimensions as the standard 705A.

Mounting Dimensions, Model 705A and All Modifications Thereof

INSTRUCTION MANUAL

MODELS 707AH & 707AK
DECIMAL COUNTING UNITS

LOT NO. _____

BERKELEY division of
Beckman Instruments Inc.

April 11 1957
Richmond, California

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.

(b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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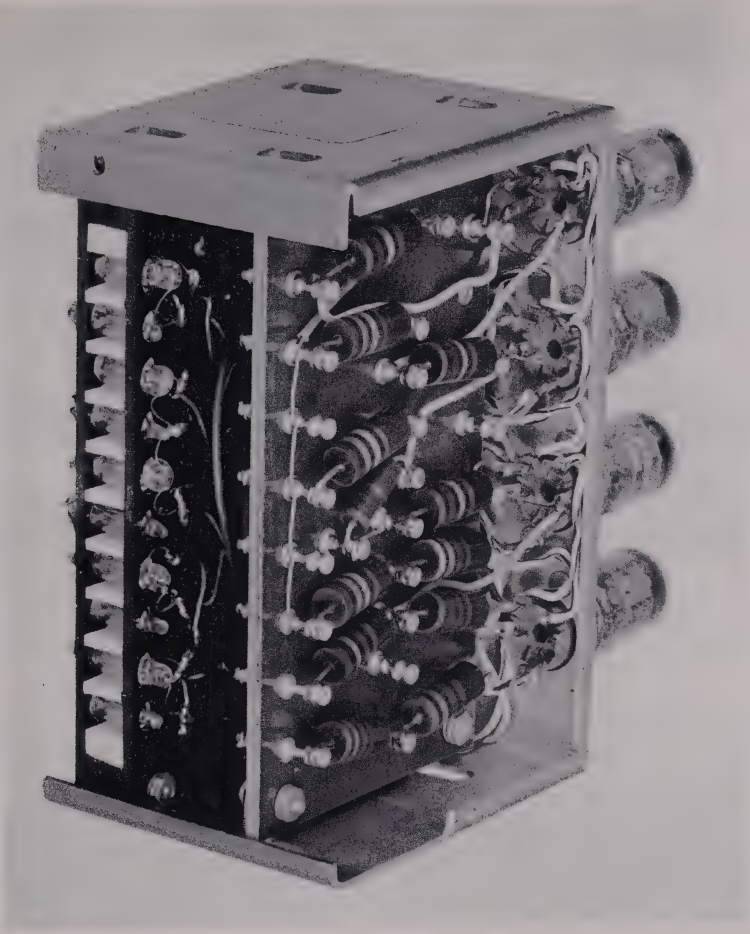
Berkeley division BECKMAN INSTRUMENTS INC.



Model 707AH Decimal Counting Unit with side covers and indicating panel removed.

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Schematic Diagram, Model 707AH, Dwg. No. 707D200

Schematic Diagram, Model 707AK, Dwg. No. 707D500

GENERAL DESCRIPTION

Models 707AH and 707AK are direct-reading, plug-in decimal counting units. The units are nearly identical except that the Model 707AK has added facilities for extinguishing the indicating lamps. Except when noted otherwise, all the information in the manual applies to both models.

A decimal counting unit registers voltage pulses applied at an input. Starting from zero it counts to nine, returning to zero on the tenth pulse and simultaneously generating an output signal. The count score is indicated by the illumination of one of ten neon lights placed behind a numbered acetate panel. This unit will count at a maximum rate of 1,000,000 pulses per second. This output is suitable for driving the Model 705A DCU or any modification thereof (705AH, 705AK, etc.) Decimal counting units may be connected in cascade (output of one to input of next), thus forming a counter whose total capacity depends only on the number of units in the chain. For example, a chain consisting of one 707AH followed by five 705AH's will count to 999,999, returning to "000,-000" on the 1,000,000th input pulse.

The unit also generates a binary-coded decimal readout in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Illuminated decimal digits

Input Requirements

Negative pulses. (See "OPERATION")

Resolution of Paired Pulses

0.8 μseconds

Maximum Counting Rate

1,000,000 Counts-per-second

Output Characteristics

Designed to drive a Model 705A DCU or any modification thereof. (See "OPERATION".)

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Power Requirements

Heaters: 6.3V a-c at 5.4 amps near ground potential.

Plates: 175 to 260 volts. (Design center is 225 volts at 60 ma.)

Construction

Plug-in unit which fits into standard 11-pin tube socket.

Dimensions

3" by 5-5/8" by 5-3/8"

Weight

1-1/2 pounds.

Tube Complement

Six type 6AL5. Four type 5687.

INSTALLATION AND OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

Mounting. Figure 1 shows the dimensions of a chassis suitable for mounting one of these DCU's next to a 705A DCU.

Input Requirements. For best operation the DCU should be driven by a type 6AS6 pentode whose plate is connected only to the input pin of the DCU. With this arrangement the DCU supplies plate voltage for the pentode and the first stage of the DCU becomes the plate load. The control grid of the pentode should be driven by positive pulses which rise from cut-off voltage to zero grid bias within 0.15 μseconds. Pulse width should be between 1.25 and 0.4 μseconds.

Output Characteristics. The output signal is a rectangular waveform generated by the 4th binary stage and appearing at pin 4 of the DCU plug. This waveform is shown in Figure 3. As every tenth pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4. With a plate supply of 225 volts, the potential at pin 4 drops from +180 volts to +90 volts. This transient can be used to drive another decimal counting unit or other circuitry. The impedance connected between pin 4 and ground must not be less than 100K or 5K in series with 100$\mu\mu$f.

Method of Resetting after a Counting Period. The unit can be reset to a registered count of either zero or nine by applying a pulse to the reset pin (pin 8) of the DCU plug. A negative pulse resets it to zero; a positive pulse to nine. The reset pin should be maintained at ground potential except when a pulse occurs. Necessary pulse amplitude depends upon pulse width: a wide pulse need not be so high as a narrow pulse. A pulse 1 μsecond wide should be at least 25 volts high. With a pulse width of 5 μseconds an amplitude of 15 volts is adequate. There is no maximum pulse width; however, the DCU will not begin counting again until the reset pin returns to ground potential.

Binary Coded Readout. The unit generates a modified binary code representing the decimal digit registered. This code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. With one exception noted below, each of the four plates is connected to a pin of the DCU plug through a 1.2M isolating resistor. In the table below, "0" represents a plate voltage of +110 volts or less and "1" represents a plate voltage of +135 volts or more.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary (Pin 2 of DCU plug)	2nd Binary (Pin 6 of DCU plug)	3rd Binary (Pin 10 of DCU plug)	4th Binary (Pin 9, 707AH Pin 4, 707AK)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps. On Model 707 AK it is possible to prevent the neon bulbs from lighting by placing -100 volts with respect to ground on pin 9 of the DCU plug. Ordinarily, the user will wish to extinguish the bulbs while the DCU is actively counting and to allow them to light, indicating the registered count, at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The DCU contains four "flip-flop" circuits. These circuits are modifications of the well-known Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one

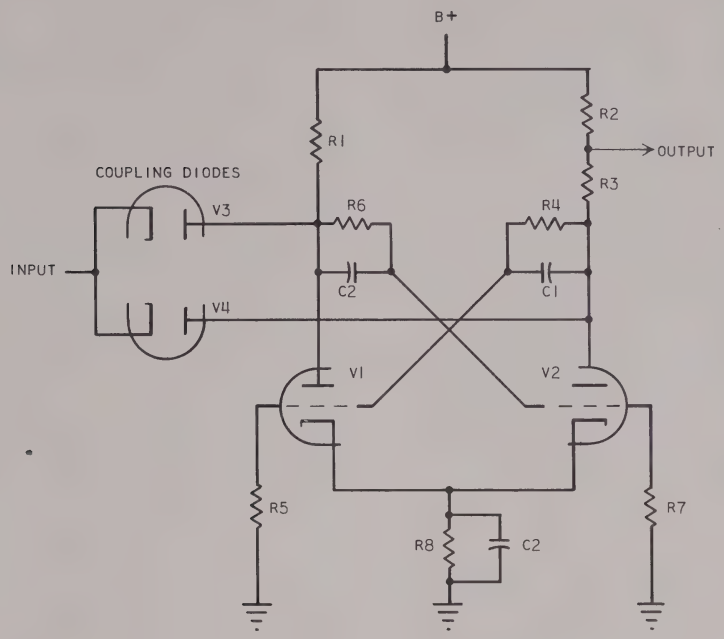


FIGURE 1. A TYPICAL BINARY.

of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R6 and R7, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R5, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that since the circuit is symmetrical the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a cross-over network (R6, R7, C2 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, re-enforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut-off and V1 is conducting at a

steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two negative input transients applied, making it a scale-of-two. The output is the drop in voltage at the junction of the plate load resistors of V2 as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of next), a counter having a scale of any power of two can be built.

The Scale of Ten. In the DCU four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by adding the equivalent of six input pulses internally. With this arrangement, the binaries pass through a complete cycle for every 10 rather than for every 16 input pulses. (See figures 2 and 3.) Assuming the unit is reset to a registered count of zero, it operates like a scale-of-16 for the first three input pulses.

When the fourth input pulse occurs, the output pulse of the 1st binary is diverted from the 2nd binary to the 4th binary. This is done by blocking the input to the 2nd binary with a clamping diode at the same time that a by-pass route from the 1st to the 4th binary is open. Since in a scale-of-16 it takes two input pulses to trigger the second binary but eight pulses to trigger the fourth binary, this action is equivalent to adding six input pulses. After the fourth input pulse, the state of the unit corresponds to a registered binary count of 10. For the next six input pulses the unit operates again like a scale-of-16, returning to a registered count of zero on the tenth pulse.

Figure 3 shows how the voltages throughout the unit change as successive input pulses occur. A voltage level lower than +120 volts corresponds to a binary digit "0". A level higher than +120 volts corresponds to a binary digit "1". Each negative transient drives the next binary except in the case of the first binary output transient which occurs at the fourth input pulse. This transient drives the fourth binary instead.

The clamping voltages are developed at the junction of plate load resistors in the output triodes of the second and fourth binaries. When the output plate of one of these binaries is in its low voltage state, the plate of the injection diode to which it is coupled through a clamping diode is held at a voltage low enough to block any negative transient at the cathode.

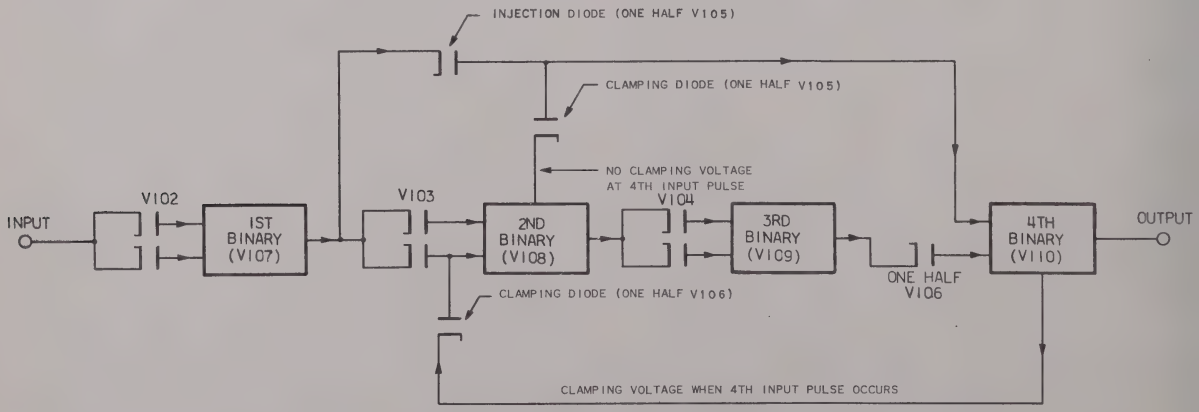


FIGURE 2. FUNCTIONAL DIAGRAM.

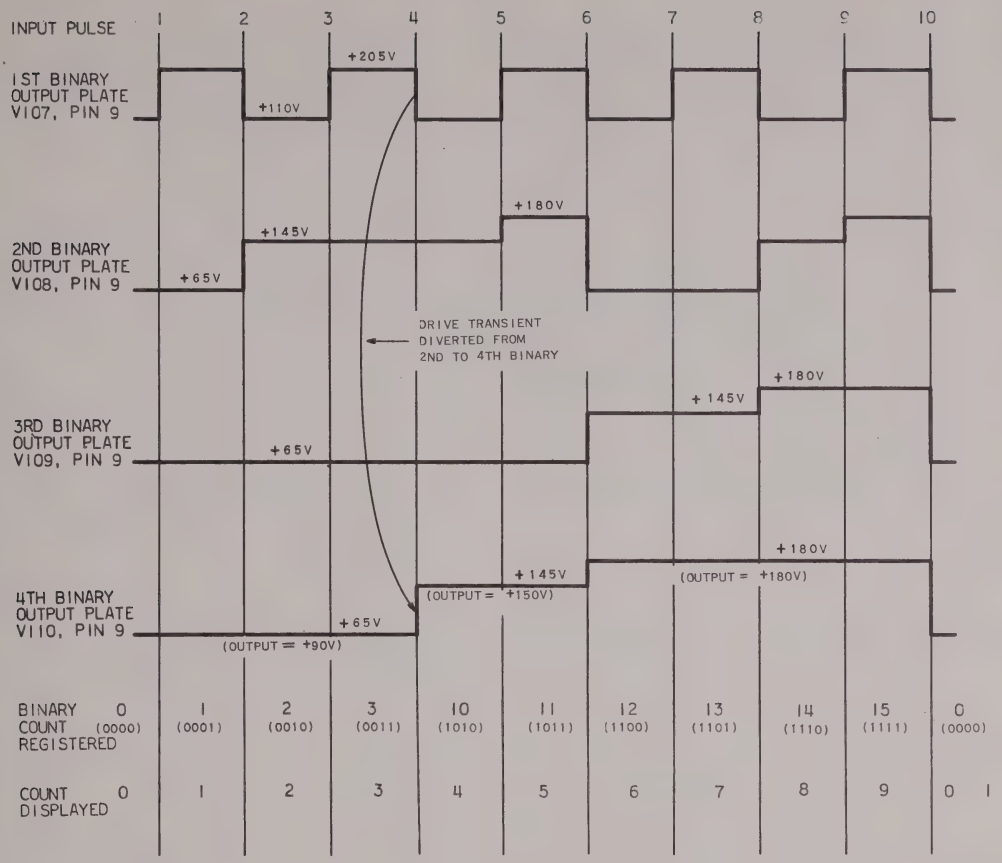


FIGURE 3. IDEALIZED WAVEFORMS.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. The counting unit is usually the indicating device of an instrument, and is quite often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 175 to 260 volts is a rough indication of permissable tolerances.

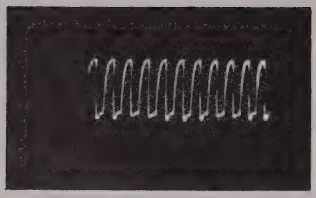
TROUBLESHOOTING CHART

NOTE: Reset unit to zero before testing for symptoms. Reset can be accomplished by momentarily applying -50VDC to reset pin.

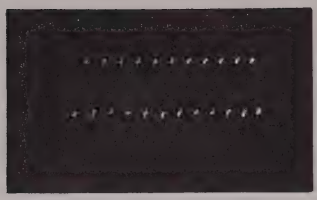
SYMPTOMS	POSSIBLE CAUSES
Unit fails to count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude. (c) Input signal of wrong polarity (d) First stage inoperative (V107).
Units counts spuriously	(a) Stray input signal. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Units count erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component
Units counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.	
1. Unit skips every other number	(a) First stage defective (V107). (b) Input circuit supplies double pulses.
2. Two stable states per cycle	
(a) Unit resets to 2. The first display cycle is 2345 and subsequent cycles are 45	Second binary (V108) defective.
(b) Units resets to 0. Display cycle is 01	Second binary (V108) or injection diode V103 defective.

(c) Unit resets to 0. The first display cycle after reset is 0123 and subsequent cycles are 23.	Fourth binary (V110) or injection diode V105 defective.
(d) Unit resets to 0. The first display cycle is 012345 and subsequent cycles are 45.	Injection diode V103 defective.
3. Four stable states per cycle. Two lamps may be lit during some of these states.	
(a) Resets to 6. Display cycle is 6789.	Third binary (V109) defective.
(b) Resets to $\frac{0}{4}$. Display cycle is $\frac{01}{45}45$.*	Third binary (V109) defective.
(c) Resets to 0. First display cycle after reset is 012345; subsequent cycles are $\frac{0}{4}145$*.	Injection diode in V104 defective.
(c) Resets to 0. First display cycle after reset is 0123456789; subsequent cycles are 6789.	Injection diode in V104 defective.
4. Eight stable states per cycle. Two lamps may be lit during some of these states.	
(a) Resets to 0 but lamp 4 is lit also while reset pin is at -50VDC. Display cycle is $\frac{01}{45}456789$.	Fourth binary (V110) defective.
(b) Resets to 0. Display cycle is 01456789.	Diode in V105 defective.
(c) Resets to 0. Display cycle is 01236789.	Diode in V106 defective.
(d) Resets to 0. First cycle after reset is 0123456789; subsequent cycles are $\frac{01}{45}456789$.	Diode in V106 defective.
5. More than ten stable states per cycle as observed on an oscilloscope.	(a) Input pulse amplitude too small. (b) Marginal tube in any stage.
6. Unit scales correctly as observed on an oscilloscope, but lighting pattern is 13579 at a slow repetition rate. No lamp lights on reset.	(a) V101 defective.
7. Unit scales correctly as observed on an oscilloscope but lighting pattern is 02468 at high frequency and at a slow repetition rate. Resets to 0.	(a) V101 defective.

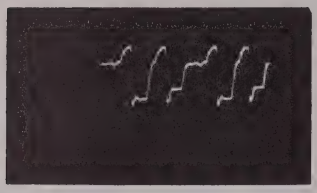
* One digit above another means both lamps are lit.



(1) First stage (Pin 9, V107) peaks at +205v and +110v.

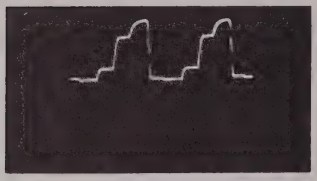


Same waveform blanked at each input pulse.

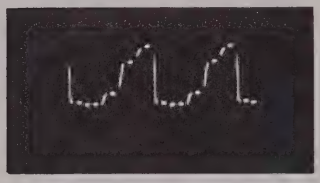


(2) Second stage (Pin 9, V108) peaks at +180v and +65v. Step at +145v.

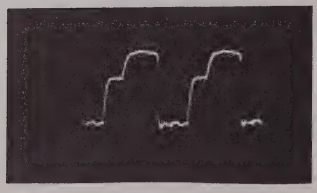
Same waveform blanked at each input pulse.



(3) Third stage (Pin 9, V109) peaks at +180v and +65v.



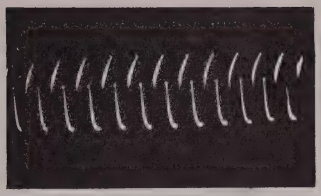
Same waveform blanked at each input pulse.



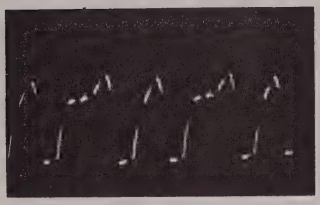
(4) Fourth stage, Pin 9, V110, UVL +180, LVL +65, step at +145, frequency 500Kc.

Same waveform blanked at each input pulse.

FIGURE 4. TYPICAL WAVEFORMS WITH 500KCS INPUT FREQUENCY.



(1) First stage, (Pin 9, V107). Peaks at +190v +105v.

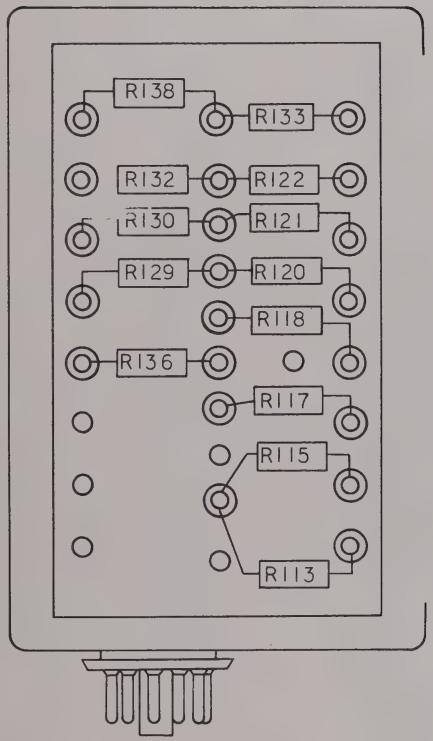


(2) Second stage (Pin 9, V108). Peaks at +180v and +65v. Step at +145v.

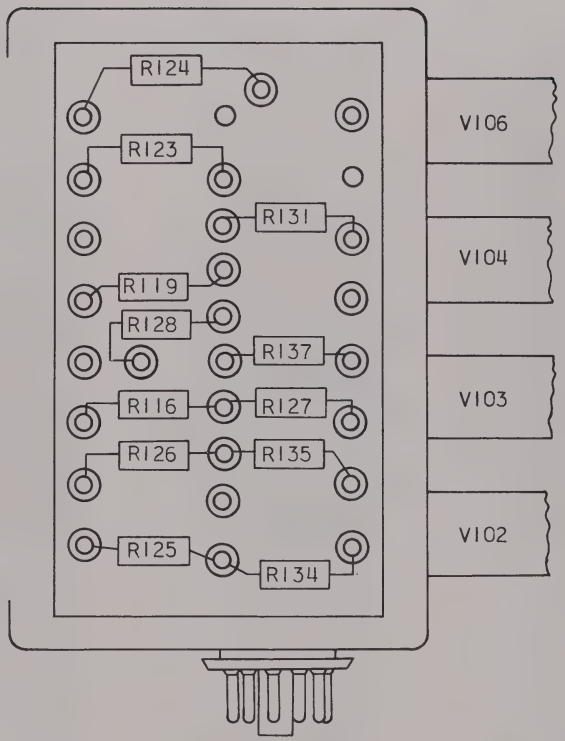
(3) Third stage (Pin 9, V109). Peaks at +180v and +65v.

(4) Fourth stage (Pin 9, V110). Peaks at +180v and +65v. Step at +145v.

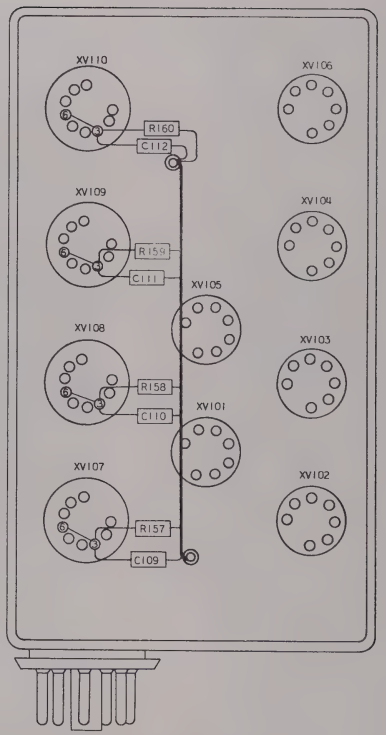
FIGURE 5. TYPICAL WAVEFORMS WITH IMCS INPUT FREQUENCY. ALL WAVEFORMS BLANKED AT TIME OF EACH INPUT PULSE.



TERMINAL BOARD, INNER SIDE



TERMINAL BOARD, SIDE EXPOSED
WHEN COVER IS REMOVED



TUBE SOCKETS VIEWED
FROM INNER SIDE.

FIGURE 7. PARTS LOCATION

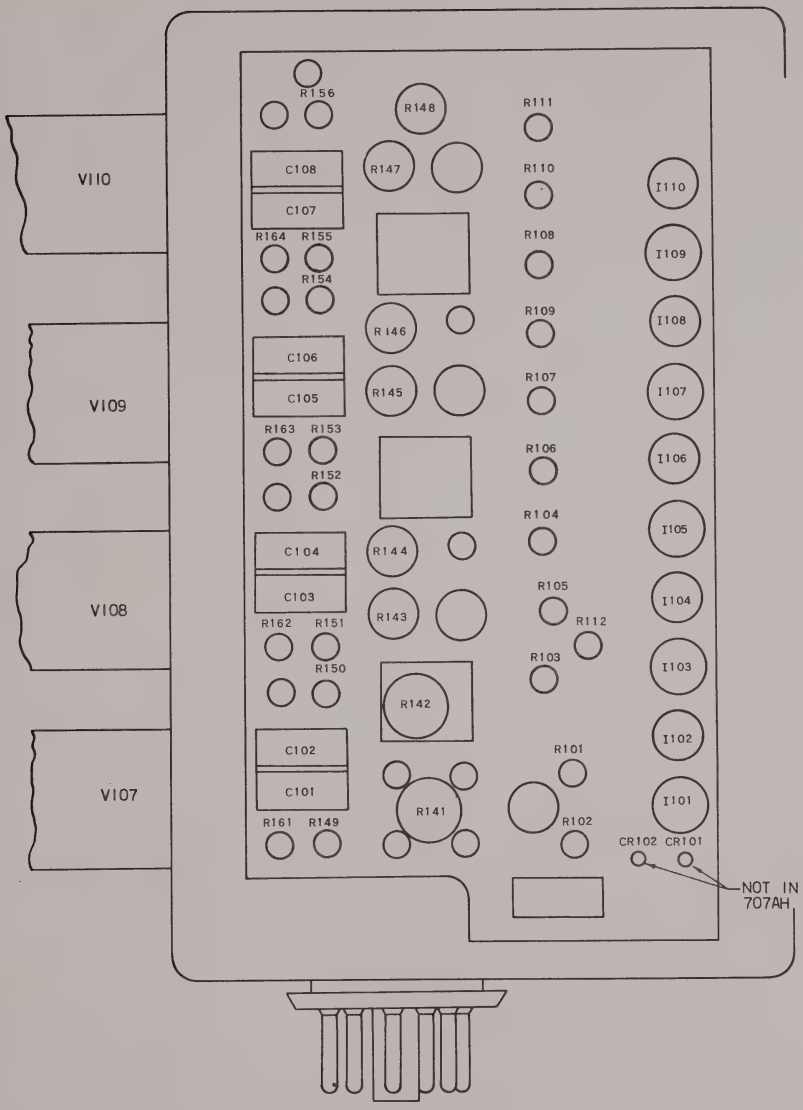
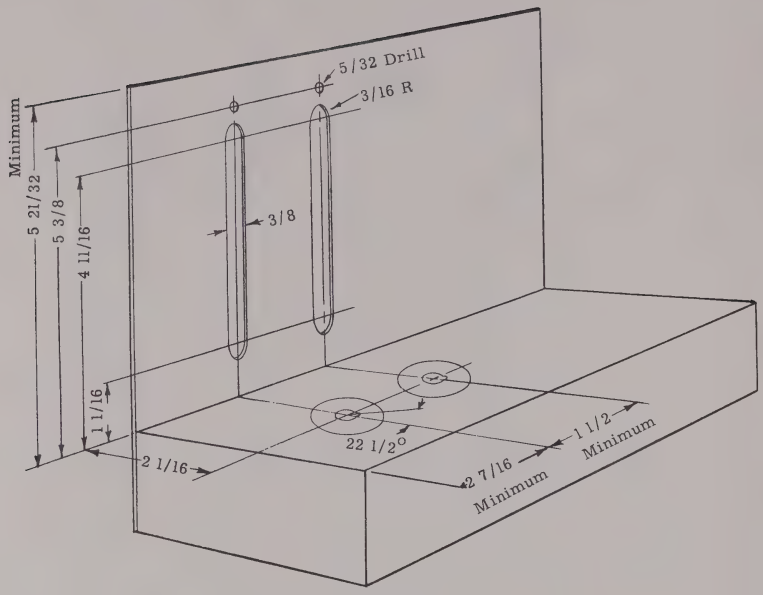


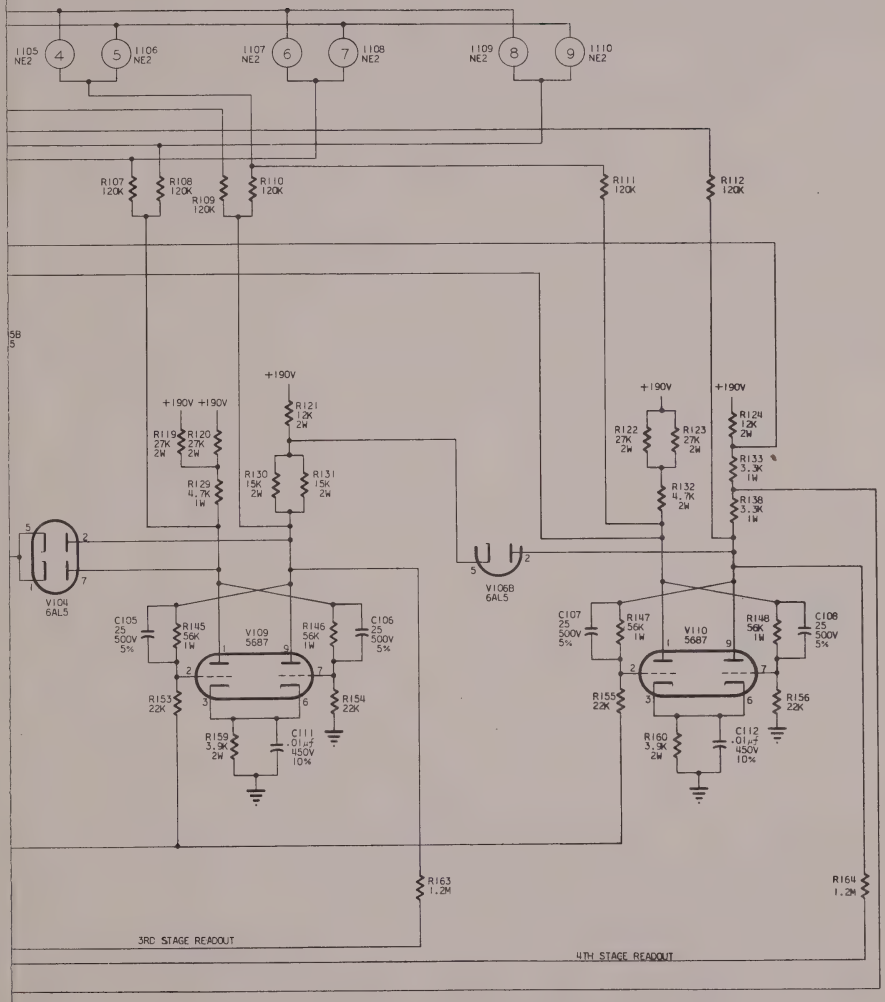
FIGURE 6. PARTS LOCATION



NOTE: Dimensions are based on the use of Amphenol "MIP" sockets mounted above the chassis.

The drawing shows chassis dimensions for mounting a Model 707A next to a Model 705A, which is customarily the next DCU in a cascade arrangement. All modifications of the Model 707A (707AH, 707AF, etc.) have precisely the same dimensions as the standard 707A. All modifications of the Model 705A have the same dimensions as that unit.

Mounting Dimensions, Model 707A and All Modifications Thereof

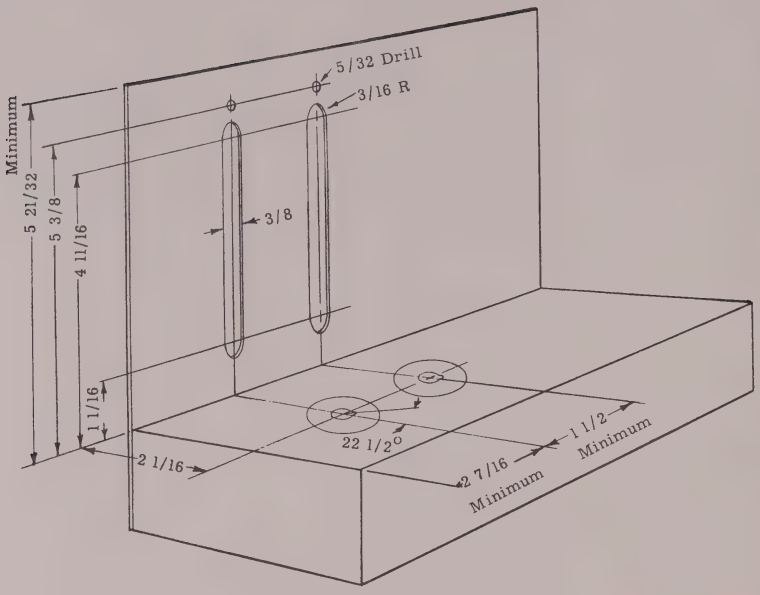


SS OTHERWISE NOTED.
ESS OTHERWISE NOTED.

NLESS OTHERWISE NOTED.

4-8-57

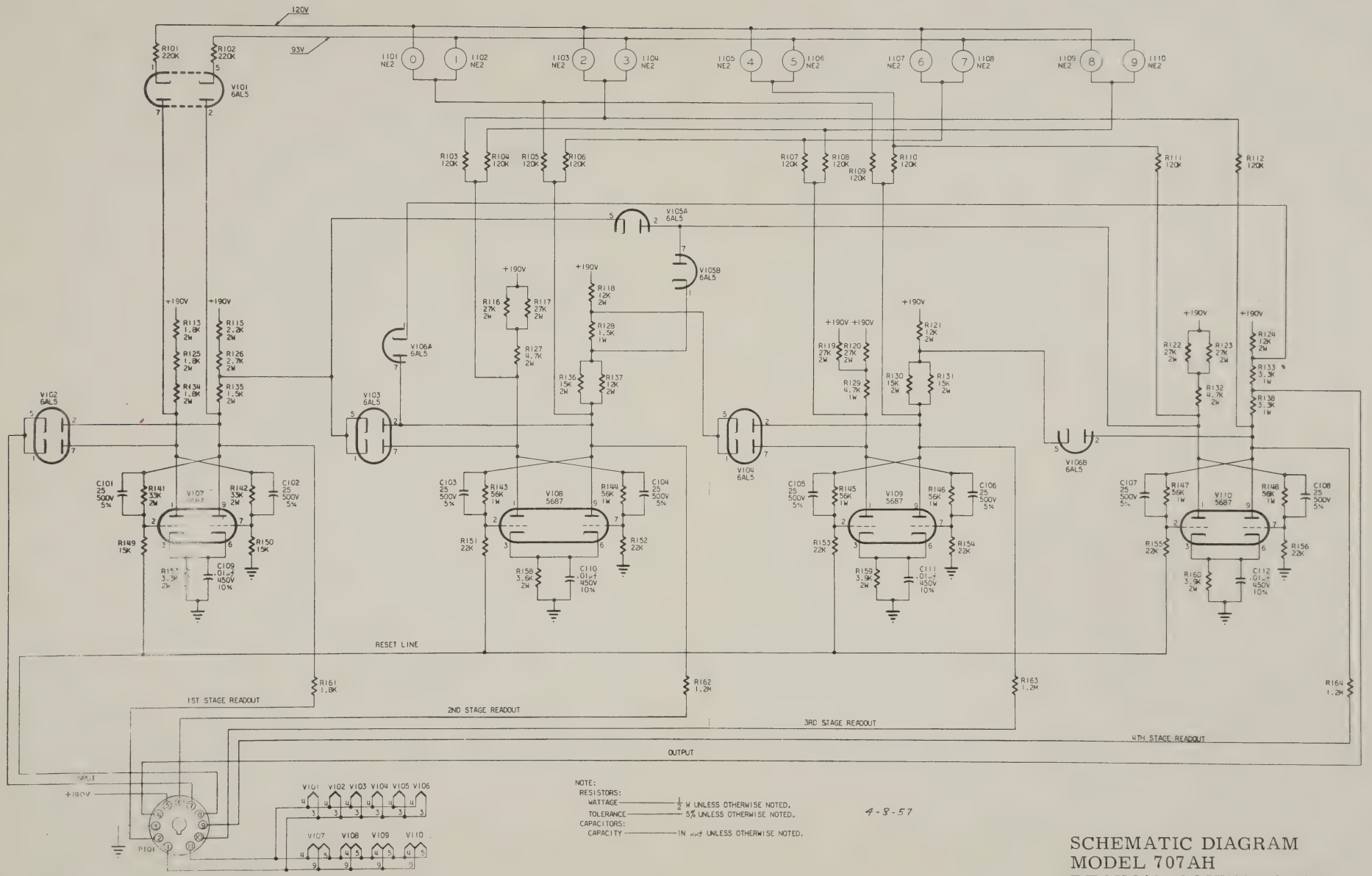
SCHEMATIC DIAGRAM
MODEL 707AH
DECIMAL COUNTING UNIT
DWG. NO. 707D200



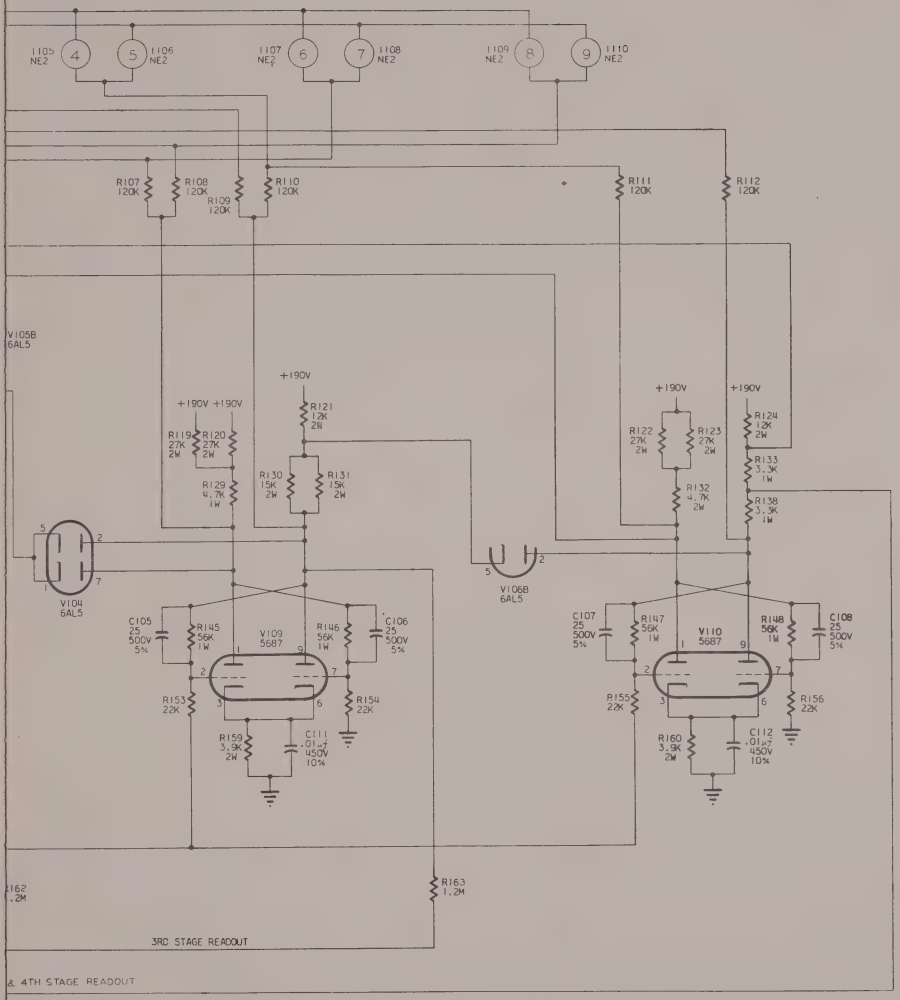
NOTE: Dimensions are based on the use of Amphenol "MIP" sockets mounted above the chassis.

The drawing shows chassis dimensions for mounting a Model 707A next to a Model 705A, which is customarily the next DCU in a cascade arrangement. All modifications of the Model 707A (707AH, 707AF, etc.) have precisely the same dimensions as the standard 707A. All modifications of the Model 705A have the same dimensions as that unit.

Mounting Dimensions, Model 707A and All Modifications Thereof



SCHEMATIC DIAGRAM
MODEL 707AH
DECIMAL COUNTING UNIT
DWG. NO. 707D200



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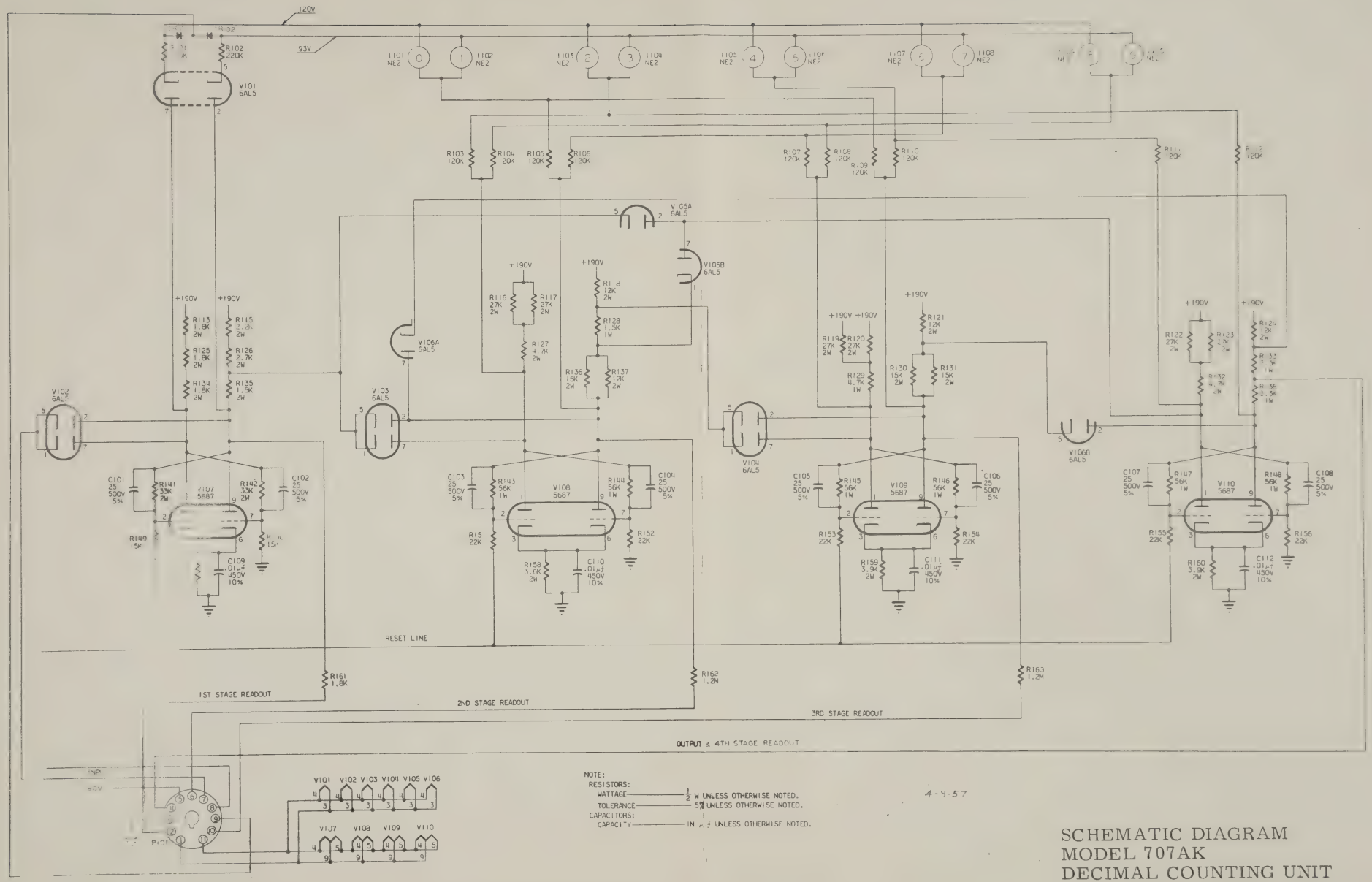
f UNLESS OTHERWISE NOTED.

4-4-57

SCHEMATIC DIAGRAM
MODEL 707AK
DECIMAL COUNTING UNIT
DWG. NO. 707D500



NOTE:
RESISTORS:
WATTAGE — $\frac{1}{2}$ W UNLESS OTHERWISE NOTED.
TOLERANCE — 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY — IN μf UNLESS OTHERWISE NOTED.

4-4-57

SCHEMATIC DIAGRAM
MODEL 707AK
DECIMAL COUNTING UNIT
DWG. NO. 707D500

INSTRUCTION MANUAL

Model 711AH
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
22 March 1956

INTRODUCTION

The Model 711AH Decimal Counting Unit is direct-reading, plug-in electronic counter. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. The maximum repetition rate of the input is two million counts per second.

The Model 711AH will drive Models 713AH which counts at 200,000 cycles per second. Model 713AH will drive Model 705AH which counts at 100,000 counts per second. These units may be cascaded to form a counter whose total capacity depends only on the number of DCU's used. Thus, six units will count to 999,999 resetting to 000,000 on the 1,000,000th pulse.

SPECIFICATIONS

Count Indication	Direct reading decimal presentation
Power Requirements	Heater: 6.3V at 1.8A
	Plates: 160 to 250 volts (design center is 190v at 55 ma)
Input Requirements	Negative pulse, 10 volt peak amplitude
Rise Time	Less than 0.12 μsec.
Duration	0.25 μsec.
Output Characteristics	Designed to drive a Model 713AH Decimal Counting Unit
Reset to Zero	Accomplished by Negative pulse to reset bus (pin 8 of the DCU plug)
Maximum Counting Rate	2,100,000 cps
Construction	Plug in unit, 11 pin socket
Dimensions	1 3/4" x 5 1/2" x 5 1/2 "
Weight	1 lb.
Tubes	4 12AV7's

OPERATION

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

Power Requirements:

Plate:	160 to 250 volts (design center is 190V at 55 ma)
Filament:	6.3 volts at 1.8 amps

Input requirements:

A negative pulse of 10 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.12 microseconds, and the duration at least 0.25 microseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the actual B+ voltage.

Output Characteristics:

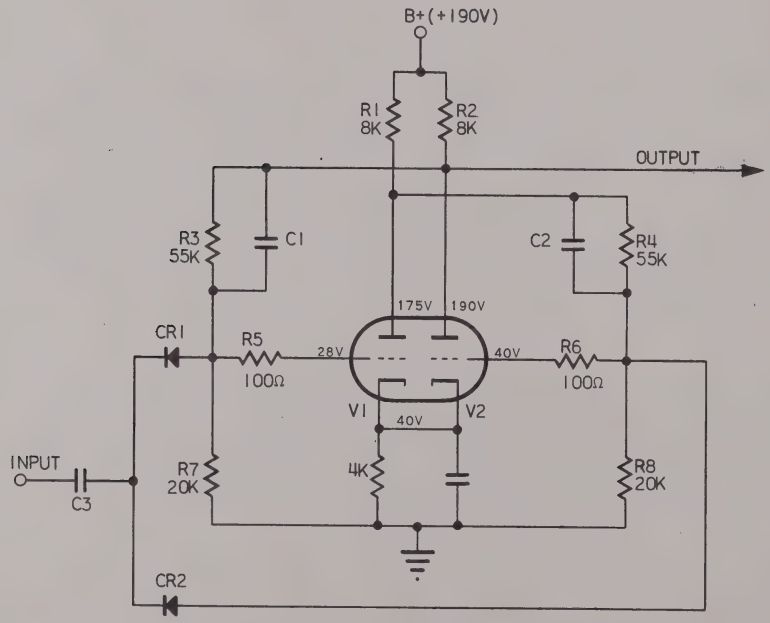
The output is a rectangular waveform as shown in Figure 3. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 125 volt; during count display "4 thru 9", 175 volts. Ordinarily, the 50-volt negative transient produced at the count of ten drives the following decimal counting unit. The load imposed on a unit must not be more than a 27,000 ohm resistor in series with a 39 $\mu\mu$f capacitor to ground.

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 3 of the 11-pin socket. Care must be taken to avoid coupling voltage surges into the input or power supply circuits.

THE BINARIES

The Model 711AH contains four "flip-flop" circuits. These circuits are modifications of the well-known Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing



VOLTAGES SHOWN ON DIAGRAM ARE THOSE EXISTING WHEN THE BINARY IS IN A STABLE STATE WITH THE RIGHT TRIODE CONDUCTING.

Figure 1 A Typical Binary (711AH)

network R3 and R7, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symetrical, the opposite state is equally stable. The circuit is triggered from one state to another by negative transients applied at the input. The input diodes form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 40 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 30 volts. CR1 will not conduct since its plate is negative of 30 volts. However CR2 will conduct and the negative transient at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cut-off. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, re-enforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut-off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale of two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built.

THE SCALE OF TEN

In the Model 711AH three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 2 is a block diagram of the circuit.

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, negative input transients) the unit operates like a simple binary counter. The output of the first binary is connected to only one grid of the gate control binary, the grid which is below cut-off when the gate is open, so that binary is not affected. At count 4 the third binary is triggered for the first time and, in turn, triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9 and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output transient which will drive another decimal counting unit.

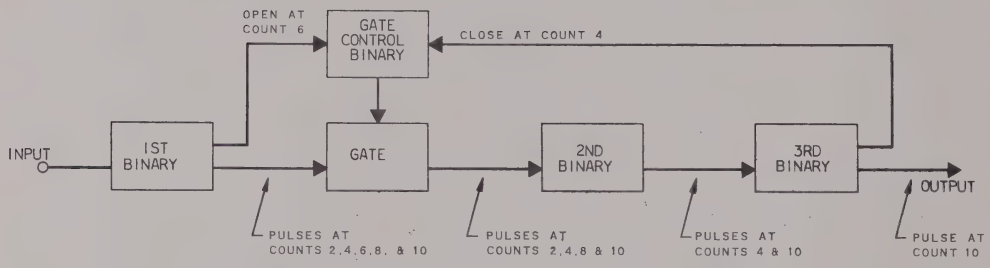


FIGURE 2 BLOCK DIAGRAM

Figure 3 shows how voltages throughout the unit change as successive counts are received. In the case of the cascaded binaries (first, second & third) voltages shown are those at the right-hand plate of each as it appears on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of two plate load resistors in the right-hand triode circuit rather than from the plate itself. These outputs vary positive and negative along with the plate voltages shown in

Figure 3 but the voltage swing is not so great. The negative transients (shown in heavy lines in Figure 3) drive succeeding binaries. One negative transient from the first binary (that which occurs at count 6) does not reach the second binary due to the action described in the paragraph below.

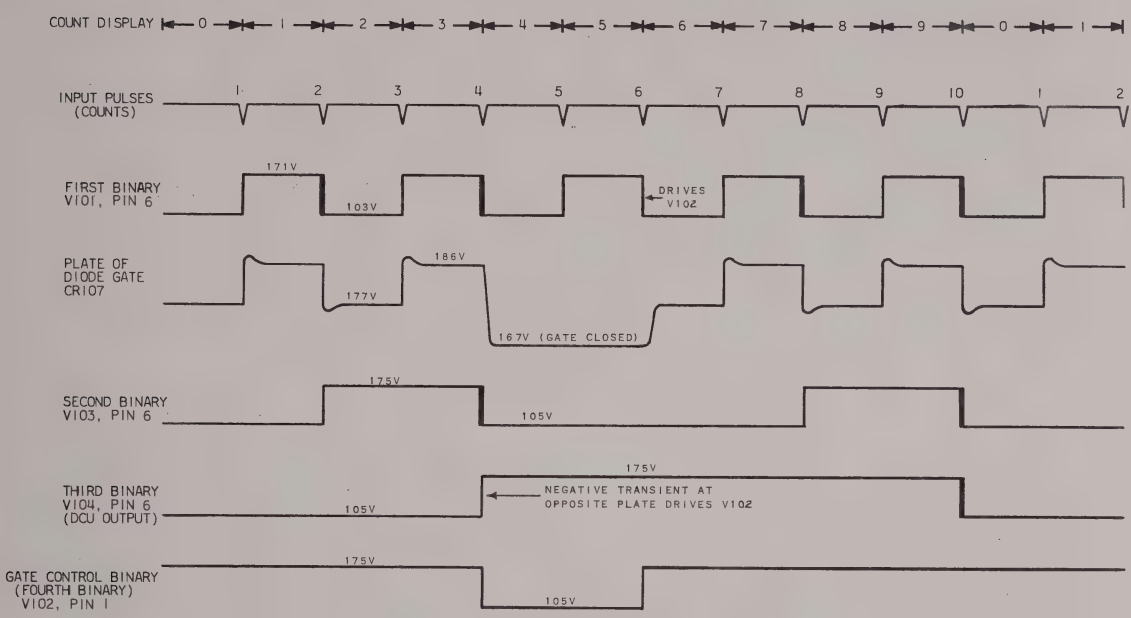

COUNT DISPLAY 0 1 2 3 4 5 6 7 8 9 0 1
INPUT PULSES (COUNTS) 1 2 3 4 5 6 7 8 9 10 1 2
FIRST BINARY V101, PIN 6
171V
103V
DRIVES V102
PLATE OF DIODE GATE CR107
186V
177V
167V (GATE CLOSED)
SECOND BINARY V103, PIN 6
175V
105V
THIRD BINARY V104, PIN 6 (DCU OUTPUT)
175V
105V
NEGATIVE TRANSIENT AT OPPOSITE PLATE DRIVES V102
GATE CONTROL BINARY (FOURTH BINARY) V102, PIN 1
175V
105V

Figure 3 Idealized Waveforms

At count 4, the voltage at the right plate of the third binary rises. This is accompanied by a simultaneous drop in voltage at the left plate. The negative transient produced at the left plate is coupled to the right grid of the gate control (4th) binary, causing it to switch to the state in which the left triode conducts. The resultant voltage drop acorss R131 causes the plate of the diode gate (CR107) to drop to +167v. Since this voltage is negative with respect to the first binary output voltage at the cathode of CR107 (which varies between +186v and +177v), the negative output transient at count 6 cannot reach the second binary. However, the negative

transient produced simultaneously at the junction of T101 and R113 is coupled to the left grid of the control binary which is now above cut-off. This switches the control binary back to its original stable state, opening the gate to pass a trigger signal to the second binary at count 8.

As the unit cycles from one thru ten, ten discreet combinations of binary states are produced. At each combination enough voltage is developed across one (and only one) of the neon indicators to light it. In addition, the right plate of each cascaded binary and the left plate of the gate control binary is connected through a resistor to a pin on the DCU plug. The readout voltages developed at these pins correspond to the voltages shown in Figure 3. When the DCU is installed in a Berkeley instrument, however, the pins are usually connected through a resistor to the B-supply, so that the voltage at the pins varies from below to above ground and back.

MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

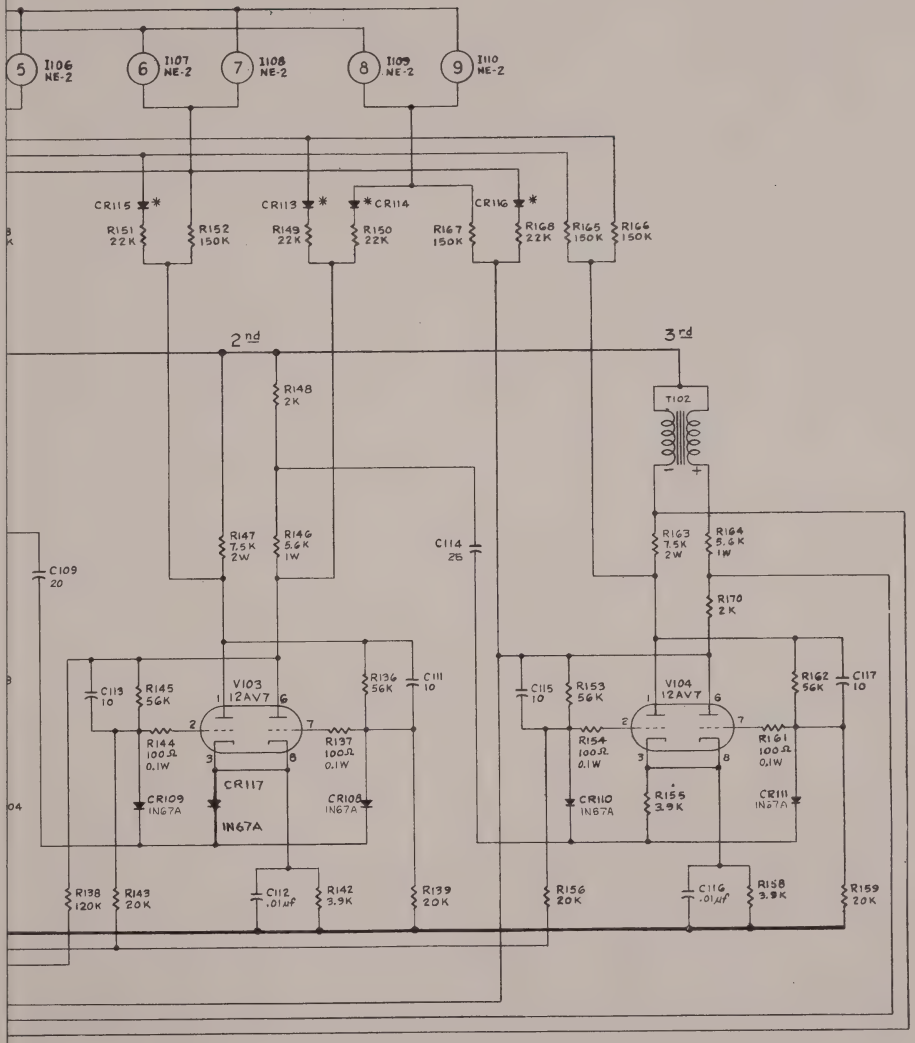
Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequency while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Faulty tubes cause most failures.

Table 1

COMMON TROUBLES*

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First stage inoperative
Unit counts spuriously	(a) Stray input signal (b) Pulses received through power supply (c) External voltages picked up by output lead
Units counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component
Unit counts in wrong sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "ON" simultaneously during a cycle provided that the number of states per cycle remains constant).	
1. Unit skips every other number	(a) First stage defective (b) Input circuit supplies double pulses
2. Two stable states per cycle	(a) 2nd stage not being driven.
3. Four stable states per cycle (0123 or 4589)	(a) 3rd stage not being driven.
4. Skips 4 and 5	(a) 4th stage not being driven by the 3rd.
5. Counts up to 4 and 5, then alternates between them as 012345-45, 45	(a) 4th stage not being driven by the 1st.
6. Skips 5 and 6	(a) 4th stage being driven by 1st on 5th input pulse.

* Reset unit before troubleshooting



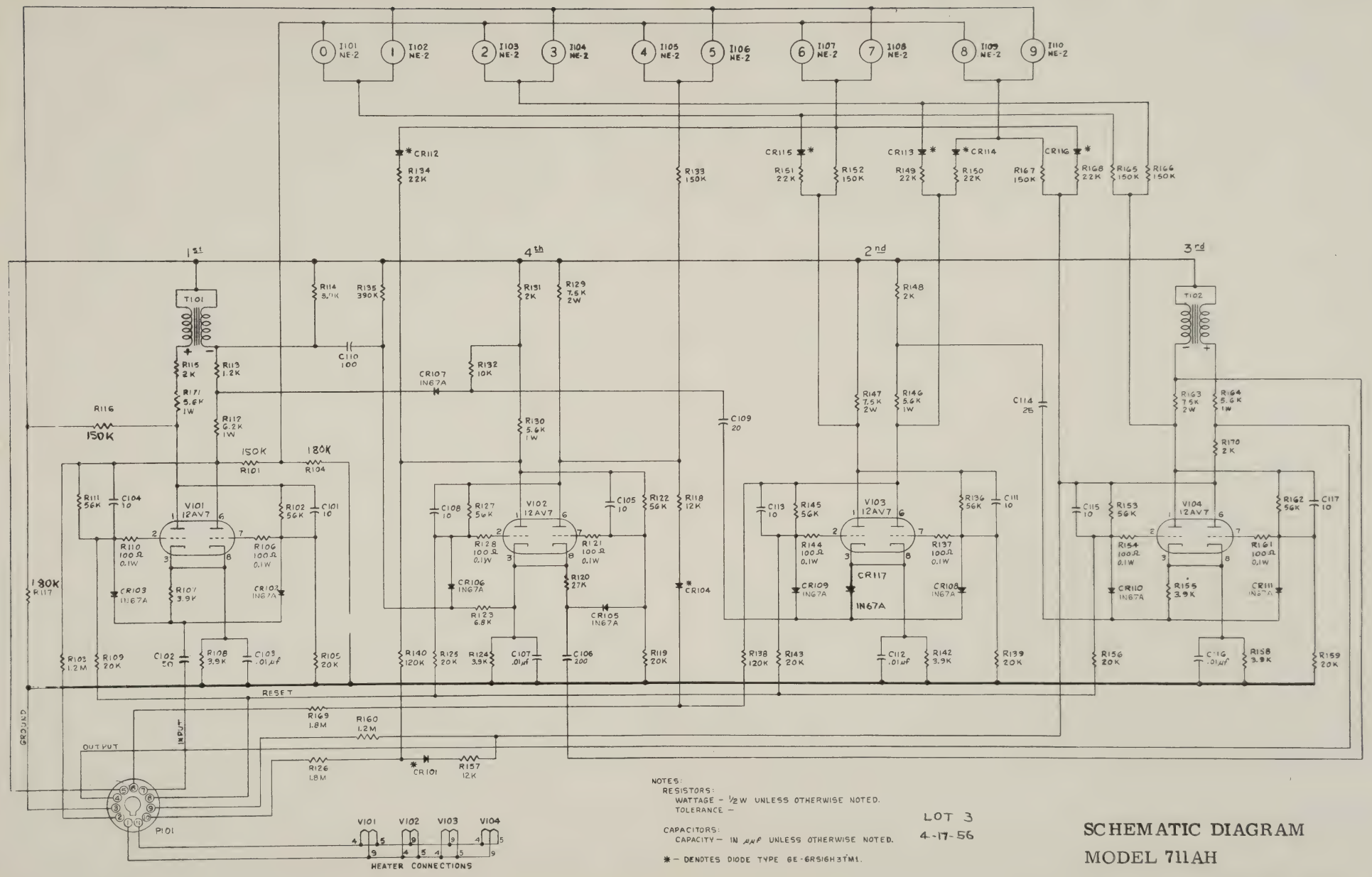
RS:
AGE – ½W UNLESS OTHERWISE NOTED.
ANCE –

ORS:
ITY – IN μμF UNLESS OTHERWISE NOTED.

OTES DIODE TYPE 6E-6RS16H3TM1.

LOT 3
4-17-56

SCHEMATIC DIAGRAM
MODEL 711AH
DECIMAL COUNTING UNIT



NOTES:
RESISTORS:
WATTAGE - ½W UNLESS OTHERWISE NOTED.
TOLERANCE -

CAPACITORS:
CAPACITY - IN μμf UNLESS OTHERWISE NOTED.

* - DENOTES DIODE TYPE GE-6RS16H3TM1.

LOT 3
4-17-56

SCHEMATIC DIAGRAM
MODEL 711AH
DECIMAL COUNTING UNIT

INSTRUCTION MANUAL

Model 713AH
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
22 March 1956

Section 1

INTRODUCTION

The Model 713AH Decimal Counting Unit is direct-reading, plug-in electronic counter. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. The maximum repetition rate of the input is 200, 000 counts per second.

The Model 713AH will drive Model 705AH which counts at 100, 000 cycles per second. These units may be cascaded to form a counter whose total capacity depends only on the number of DCU's used. Thus, six units will count 999, 999, resetting to 000, 000 on the 1, 000, 000th pulse.

Specifications

Count Indication	Direct reading decimal presentation
Power Requirements	Heater: 6. 3V at 1. 8A
	Plates: 150 to 230 V (design center is 190V at 20 ma)
Input Requirement Recommended	Negative pulse 50 volt peak amplitude
Rise Time	Less than 0. 5 μsec.
Duration	1. 0 μsec.
Output Characteristics	Designed to drive a Model 705AH Decimal Counting Unit.
Reset to Zero	Accomplished by Negative Pulse to reset bus (pin 8 of the DCU plug)
Maximum Counting Rate	200, 000 cps
Construction	Plug-in unit, 11-pin socket
Dimensions	1 3/4" x 5 1/2" x 5 1/2"
Weight	1 lb.
Tubes	4 12AV7's

Section 2

OPERATION

Installation

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

Operation

Plate	150 to 230 volts (design center is 190V at 20 ma)
Filament	6.3 volts at 1.8 amps

Input requirements:

A negative transient of 50 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.5 μseconds, and the duration at least 1.0 μseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the supply.

Output characteristics:

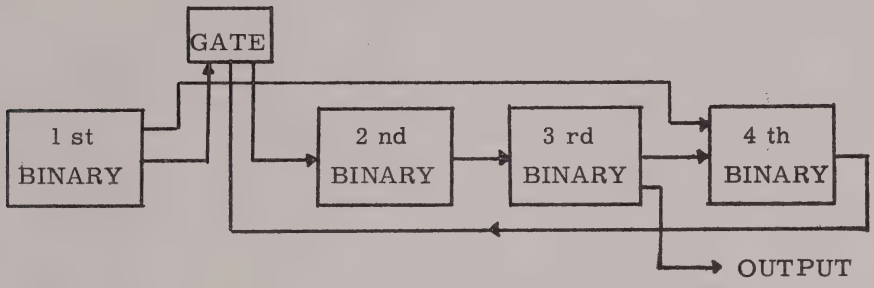
The output is a rectangular waveform as shown in Figure 2. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 60 volts; during count display "4" thru "9", 130 volts. Ordinarily, the 50-volt negative transient produced at count ten drives the following decimal counting unit. The load imposed on a unit must not be more than a 10,000 Ω resistor in series with a 100 μμfd capacitor to ground.

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 3 of the 11 pin socket. Care must be taken to avoid coupling voltage surges into the input or power supply circuits.

Section 3

THEORY OF OPERATION

The basic circuit of the Model 713AH is a modified Eccles-Jordan Trigger Circuit having two stable states. This circuit is referred to here as a "binary". See the Model 711AH manual for the basic theory of the binary. The binary circuit used in the Model 713AH is basically the same as that in the Model 711AH except for the method of triggering:



FUNCTIONAL DIAGRAM MODEL 713AH

Figure 1

In the Model 713AH, four binaries or flip-flops are connected in cascade making a scale of 16. It is permuted to a scale of 10 by a diode gating system. On the count of 0 (zero) the unit is reset to the equivalent of binary 4. It counts as a binary counter until the count of 4 at which time the 4th stage is triggered for the first time. This closes the gate to the second stage preventing it from being driven until the 4th stage is triggered back to its original state, by the first stage, on the count of 6. From this count until the count of 0 (zero) the unit again counts as a binary counter. Gating off the second stage for 2 counts and driving the fourth from the first has the effect of adding six counts internally making the unit a scale of 10.

Section 4

MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

Troubleshooting

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Faulty tubes cause most failures.

Diagrams and Tables

Figure 2 shows the idealized waveforms of each stage when the DCU is working properly. A study of these and the corresponding ones of a faulty unit will help in locating components and tube failures. Nominal voltages are shown on the waveforms of Figure 2. These may vary considerably as tubes and components age.

Table 1

COMMON TROUBLES*

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First stage inoperative
Unit counts spuriously	(a) Stray input signal (b) Pulses received through power supply (c) External voltages picked up by output lead
Unit counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component
Unit counts in wrong sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant.)	
1. Unit skips every other number	(a) First stage defective (b) Input circuit supplies double pulses
2. Two stable states per cycle	(a) 2nd stage not being driven.
3. Four stable states per cycle (0123 or 4589)	(a) 3rd stage not being driven.
4. Skips 4 and 5	(a) 4th stage not being driven by the 3rd.
5. Counts up to 4 and 5, then alternates between them as 012345-45, 45	(a) 4th stage not being driven by the 1st.
6. Skips 5 and 6	(a) 4th stage being driven by 1st on 5th input pulse.

* Reset unit before troubleshooting

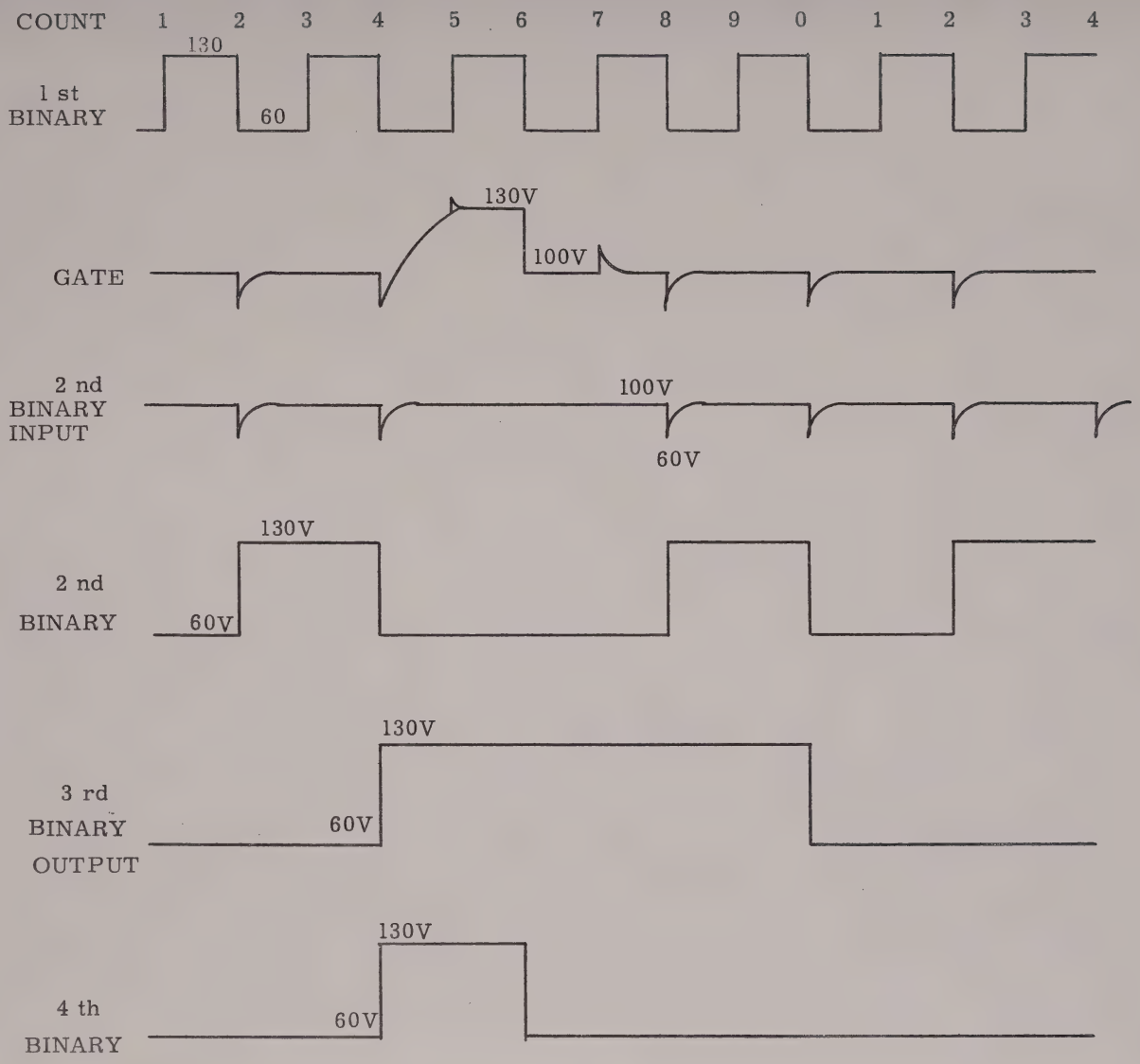
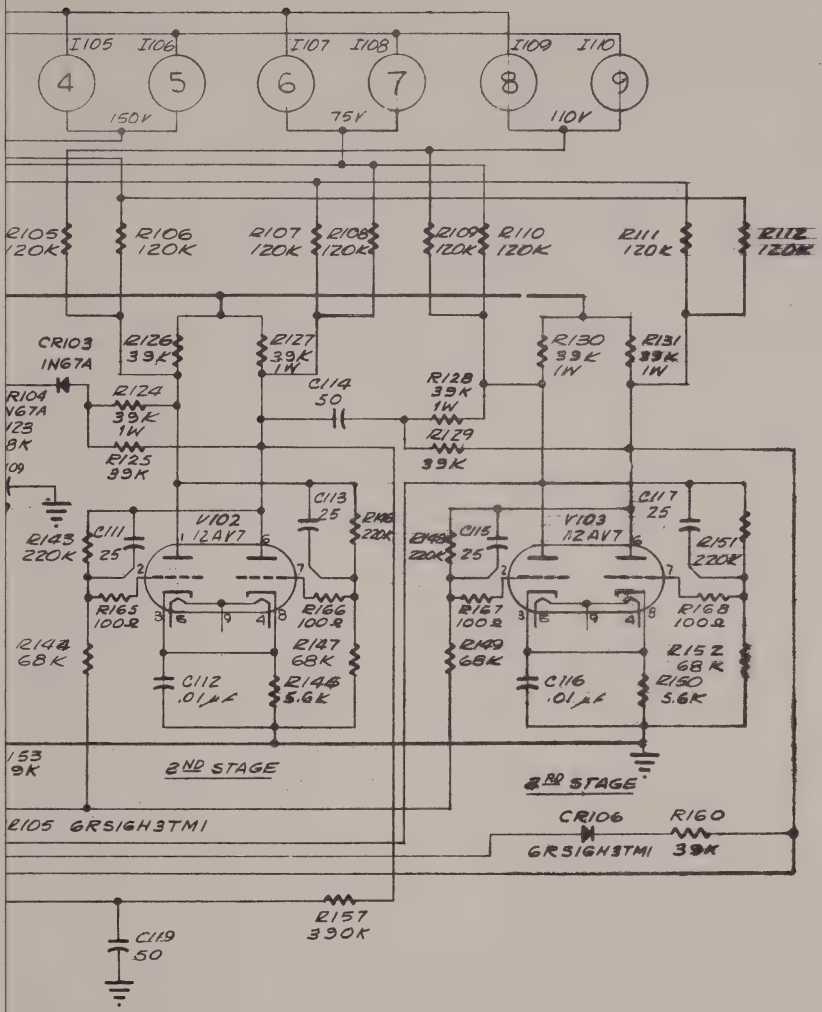


FIGURE 2 PLATE WAVEFORMS - PIN 6



LOT 3
5-11-56

SCHEMATIC DIAGRAM
MODEL 713AH
DECIMAL COUNTING UNIT

Insert

Foldout / Ma

Here

summer, 1957

short form catalog c-704

Berkeley digital and analog instrumentation

COUNTING, TIMING, FREQUENCY MEASURING EQUIPMENT

• EPUT® Meters • Universal EPUT® Meters • Frequency Measuring Equipment • Preset Counter Controllers • Time Interval Meters • Electronic Counters • Nuclear Scalers and Count Rate Meters • Digital Recorders • Inline Readouts • Transducers • Decimal Counting Units

SPECIAL AND GENERAL PURPOSE TEST INSTRUMENTS

• Expanded Scale Volt Meters • Expanded Scale Frequency Meters • Resistance Bridges • Double Pulse Generators

*EASE** ANALOG COMPUTERS AND *EASE** PRECISION COMPONENTS FOR CONTROL SYSTEMS

*T.M.

Beckman® / *Berkeley Division*
A Division of Beckman Instruments, Inc.
2200 Wright Avenue, Richmond, California
Phone LAndscape 6-7730 TWX Richmond 433

Beckman/Berkeley Division, now in its second decade, supplies industry and science throughout the world with two hundred types of electronic counting, control and computing equipment.

An organization of highly skilled and experienced engineers, designers and production workers, Berkeley is equipped to mass produce a wide range of instruments for science and industry. Techniques for the mass production and assembly of high speed counters, timers and frequency measuring equipment originated at Berkeley.

Facilities at Berkeley are by no means limited to quantity production of standard type instruments. The Engineering Department conducts research development and product design operations in four major fields of electronic interest—counting, timing, and frequency measuring equipment, analog computers, nuclear test instruments and special products.

Naturally this stress on research and development has resulted in important electronic "firsts" at Berkeley. Some of these include:

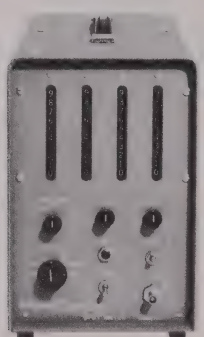
The first 1,000,000 count per second events-per-unit-time meter (EPUT®)
The original electronic decade unit (DCU)
The first direct reading time interval meter for measuring time intervals to one microsecond.
The first console style push-button analog computer (EASE*)
The first direct reading frequency meter
The first digital recorder with printed readout
The first in-line, in-plane digital indicator
The FERRISTOR*, miniature vacuum tube replacement

EPUT® meters

Berkeley EPUT® Meters automatically count and display the number of events that occur during a precise time interval. Events may be any physical occurrences that can be represented by changing voltages occurring either regularly or at random rates to 1,000,000 per second.

APPLICATIONS

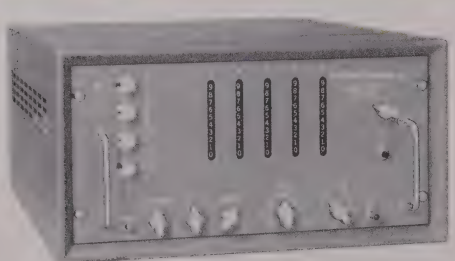
Precision tachometry; measurement of pressure, flow, temperature, viscosity, velocity, frequency, frequency period; process control or data reduction systems; calibration of frequency generating equipment; measurement of any electrical, mechanical, optical or other physical event occurring during a precise time interval.



New Model 5210 100 KC EPUT® Meter for industrial and field application. Light, small, portable. Simple to operate. Straightforward design and construction. Reliable. The 5200 Series use same DCUs as other Berkeley equipment.

7000 Series units may be used to measure frequency or period, and also as high speed electronic counters with manual on-off control. Model 7160 shown.

BRIEF SPECIFICATIONS	Model 5210	Model 7150	Model 7151	Model 7160	Model 7161	Model 7650
Count Capacity:	4 digits	5 digits	5 digits	6 digits	6 digits	5 digits
Count Rate:	0 cps to 100 KC	0 cps to 100 KC	0 cps to 100 KC	0 cps to 1 mc	0 cps to 1 mc	0-40,000 cps
Time Bases: (decade steps)	0.1 and 1 sec	10 μsec to 1 sec	Time Interval Generator	1 μsec to 1 sec	Time Interval Generator	0.1 to 10 sec
Binary coded output to drive digital printer	optional $30.00 extra	yes	yes	yes	yes	yes
Price:	$475.00	$775.00	$1195.00	$995.00	$1345.00	$1495.00



New Models 7151 and 7161 Preset EPUT® Meters feature a variable time base. Time base dividers have been replaced by preset DCUs. In addition to specifications below, these instruments feature several unique operating functions: Totalize — divides frequency between 0 and 10 KC by any number from 1 to 10,000; TIG — generates frequencies from 0.1 to 10^5 milliseconds.

*T.M.

Model 7650 Long Life Magnetic EPUT® Meter performs the same function as models described above. Uses Berkeley FERRISTORS* in all critical circuits to assure continuous-duty reliability. Ideally suited to industrial test applications such as jet and piston-engine test cells, etc. Has digital "count-down" time base for precise gating; no adjustment of time base required.

Universal EPUT® Meters

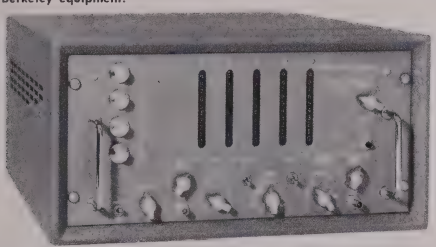
These truly universal instruments combine high-speed electronic counting with a precision time base in multi-purpose circuitry. They function as counters, timers, time-interval meters, EPUT® meters, frequency, frequency ratio or period meters, or as secondary frequency standards.

APPLICATIONS

Counting, time interval, events-per-unit time measurements for precision tachometry, measurement of pressure, flow, frequency, velocity, viscosity, elasticity; timing relay, shutter action, etc. Measurement of unknown frequencies, frequency ratios, periods, etc.

BRIEF SPECIFICATIONS	Model 5230	Model 7350	Model 7351	Model 7360	Model 7361
Ranges-Frequency:	0 cps to 100 kc	0 cps to 100 kc	0 cps to 100 kc	0 cps to 1 mc	0 cps to 1 mc
Time Interval:	100 μsec to 10^4 sec	10 μsec to 10^6 sec	10 μsec to 10^2 sec	1 μsec to 10^7 sec	10 μsec to 10^3 sec
Period:	0 cps to 10 kc	0 cps to 100 kc	0 cps to 10 kc	0 cps to 1 mc	0 cps to 10 kc
Time Bases:	0.1 and 1 sec	10 μsec to 10 sec	Time Interval Generator	1 μsec to 10 sec	Time Interval Generator
Binary coded output information for driving digital recorder	$30.00 extra	yes	yes	yes	yes
Price:	$575.00	$945.00	$1295.00	$1245.00	$1445.00

New Model 5230 100 kc Universal EPUT® Meter for industrial and field application. Light, small, portable. Simple to operate. Straightforward design and construction. Reliable. The 5200 Series uses same DCUs as other Berkeley equipment.



New Models 7351 and 7361 Preset Universal EPUT® Meters features are similar to Models 7150 and 7160 with variable time base feature, etc. In addition, TIM and A/B functions are offered.

Model 7360 Universal EPUT® and Timer.

Frequency Measuring Equipment

Basic instrument is the Model 5571, capable of measuring frequencies from 0 cps to 42 mc. Addition of the Model 5580 UHF-VHF converter and suitable plug-ins extends the range to 515 mc; Model 5582B VHF converter with plug-ins extends the range to 1,005 mc. Results are displayed in direct-reading digital form. Unit will drive a Model 1452 digital printer to provide a complete frequency logging system in which results are printed on standard adding machine tape. Model 5571 is also a Universal EPUT® Meter with same specifications as Model 7360.

New Model 905 WWV receiver is most convenient, reliable method of utilizing standard time and frequency broadcasts from NBS stations WWV and WWVH. Features: covers all six WWV and WWVH frequencies, crystal controlled, separate crystal for each channel, built-in audio filters. Price: $525.00 (Rack) $550.00 (Cabinet).

Complete frequency logging system for frequencies to 1,000 mc. Model 5571 (with 5582B converter and plug-ins), drives Model 1452 digital printer to record results automatically on adding machine tape, 905 WWV receiver.

Model 5571 with 5580 converter and 5580 series plug-ins for frequencies to 515 mc. Model 5571 price, $1825. Model 5580 converter, $300.00. 5581 series plug-ins, $125.00 to $175.00 each. All are FCC-approved. Model 5571 shown.

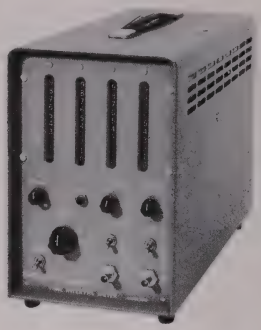
Time Interval Meters

Any event delineated by varying voltages may be timed. All models may be standardized against WWV or other external standards. Provisions are also made to measure period of input signals, use as a high-speed electronic counter, or frequency ratio meter.

APPLICATIONS

Timing of relays, shutters, solenoids, controls; ballistics research; measurement of viscosity, elasticity, velocity; accurate low frequency and period measurements, frequency ratio measurements, etc.

BRIEF SPECIFICATIONS	Model 5220	Model 7250	Model 7260
Range:	100 μsec to 1 sec	10 μsec to 1 sec	1 μsec to 1 sec
Accuracy:	$\pm$ 100 μsec $\pm$ 1 part in 10^4	$\pm$ 10 μsec, $\pm$ 1 part in 10^5	$\pm$ 1 μsec, $\pm$ 1 part in 10^6
Input Requirements:	0.25v rms, 1 megohm dc-coupled.	0.1v rms, 10 megohms, ac or dc-coupled.	
Display Time:	Adjustable .05 to 5 sec.	Adjustable, 0.1 to 10 seconds (automatic reset). Manual reset also provided.	
Binary-coded output to drive Digital Printer	Optional $30.00 extra	yes	yes
Price: (f.o.b. Factory)	$475.00	$595.00	$830.00



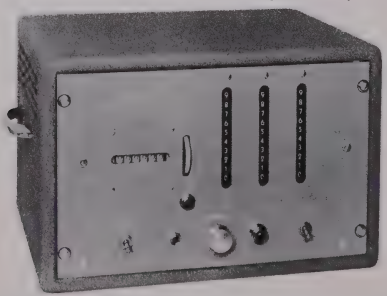
New Model 5220 100 μsec to 1 sec time interval meter for industrial and field applications.

Model 7250 Berkeley Time Interval Meters provide a direct digital reading of elapsed time between any two events, or the duration of a single event, in microsecond (Model 7260) or 10-microsecond increments.

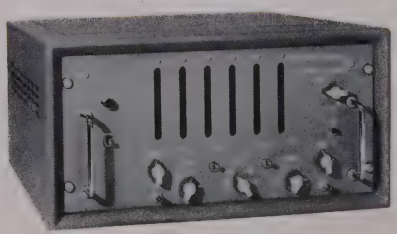
Electronic Counters

BRIEF SPECIFICATIONS	Model 5001	Model 5010	Model 7050	Model 7060
Counting Rate:	0-125 cps	0-10,000 cps	0-100KC	0-1 mc
Sensitivity:	0.5 volts peak	0.5 volts peak	0.1 volts rms.	0.1 volts rms
Binary coded output to drive Digital Printer	no	no	yes	yes
Price:	$195.00	$330.00	$545.00	$645.00

Model 5001 (125 cps) industrial type electronic counter for use where speed requirements are in excess of the limitations on mechanical registers (10 cps).



The Berkeley Industrial Counter, Model 5010 (10 KC), is a highspeed electronic counting instrument designed to fill general counting needs, where speed requirements are greatly in excess of those possible with mechanical counters.



New Models 7050 (100 kc) and 7060 (1mc) gating counters offer both manual and electronic gating. Gate control signals may be of any frequency from d-c to maximum counting rate of the instrument with no input waveform restrictions. For use as frequency ratio meters, digital flow computers, slave EPUT® or time interval meters, high speed counters. Shown Model 7060.

Preset Counter-Controllers

Counts at rates to 40,000 cps, yields output signals at any desired preset total (or any two preset counts with dual preset models). Operates on input pulse of ± 1 volt peak, or more. Instantaneous reset to zero after final count. Reliable, simple to operate. Available in 2, 3, 4, 5, and 6-digit capacities. Long-life magnetic Model 5840 dual preset features FERRISTOR* circuitry for continuous-duty reliability. Typical applications: coil winding, automatic packaging, sorting to length, motor speed control.

Series 5840 long-life magnetic dual preset counter features FERRISTOR* circuitry; 4-digit, $1115.00; 5-digit, $1200.00; 6-digit, $1295.00.

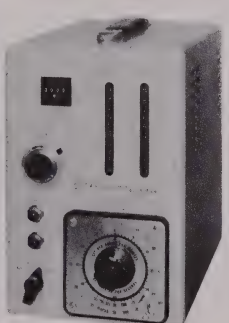
Series 5420 single preset models range in price from $435.00 for 2-digit capacity to $740.00 for 6-digit capacity. Dual preset Series 5440 range from $650.00 (2-digit) to $895.00 (6-digit).

Nuclear Scalers

Berkeley's long experience in counting techniques has been carried over to the nuclear field to produce a line of high quality scalers. Model 2025, basically a gated decimal counter, will count, store and record any phenomena occurring in a random fashion. It features automatic reset and start, uses DCUs instead of mechanical registers, and is designed for use with an electronic timer (Model 811) for increased accuracy.

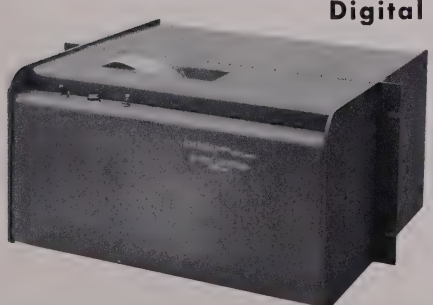
BRIEF SPECIFICATIONS	
	Model 2025
Input:	Pulse Height discriminator with range +5 to +50 volts
Scaling Circuit:	Paired Pulse Resolution: Better than 1 μsec
Integral Amplifiers:	Input Sensitivity: 1 millivolt ± 20%
Controls:	Preset Count Selector — 100 to 4 million in 1-2-4 steps
Price:	$950

BRIEF SPECIFICATIONS	
	Model 2101
Input Sensitivity:	0.25 volts
Resolving Time:	5 μseconds
Reset:	Reset of register and counting units by single lever
Timer:	Indicates and times automatically to closest second up to 60 min. Accuracy ± 0.2 sec
Price:	$595.00



This scaler weighs only 24 pounds and offers maximum convenience for laboratory work and medical diagnosis. Can be used directly with G-M tubes and scintillation counters. Extremely reliable and simple to operate.

Digital Recorders, Inline Readouts & Transducers

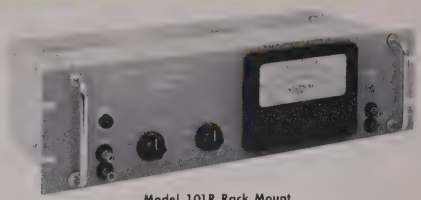


MODEL 1452 DIGITAL PRINTER. Automatically and permanently records information from any Berkeley 5510, 5571 or 7000 Series instrument, prints data in digital form on standard adding machine tape from printer and scanner in one compact unit. May be modified to print "Time" or "Code" information simultaneously with data. Rack or bench mounted: available in up to 8 digits. One printout every 0.85 seconds. Price (6-digit), $950.00.

MODEL 5916 IN-LINE READOUT. Large, illuminated in-line IN-PLANE figures reduce fatigue and error. Ideal for remote observation of data. Connects directly to any Berkeley 5510, 5571 or 7000 Series instrument. Presentation rate up to 15 per second; accepts binary voltages. Price $775.00.

TRANSDUCERS. A large number of transducers especially designed for use with Berkeley counting, timing, and frequency measuring equipment are available. These include tachometer, pickups, photocells, and light sources. Specifications and technical description on request.

Expanded Scale Voltmeter



Model 101R Rack Mount.

Model 101-50 expanded scale voltmeter. Featuring: ± 0.25% accuracy, true rms reading, easy to read expanded scale, direct connection for 1 MA recorder.

Brief Specifications: Accuracy—± 0.25% of input voltage; Voltage Indicated—True rms; Voltage Range—100-500 (50-250v); Frequency Range —50-2,000 cps; Scale Range—12v (6v); Price: $360.00 (rack mounted $400.00).

Expanded Scale Frequency Meter

Expanded Scale Frequency Meters are designed for fast accurate monitoring of frequencies near 400 cps. They were originally intended for use in making production inspection measurements of the frequency regulation of motor and engine driven generating units, but many other applications where a record of frequency is desired have been found.

The Model 404 expanded scale frequency meter features Accuracy of ± ½ cycle, 1 MA Recorder Connection Provided; Expanded Scale for easy, error-free reading.

Brief Specifications: Base Frequency—400 cps; Span—± 25 cycles; Accuracy—± ½ cycle; Price—$330.00 (rack mount $380.00).

The Model 100 Transformation Ratio Meter is an RMS reading expanded scale voltmeter designed to read the primary and secondary voltages of synchros faster and easier than by conventional methods. The method of operation is ideally suited for production testing as well as for inspection of synchros and control transformers.

Features: ± 0.2% Accuracy; RMS Reading; Expanded Scale; Read Directly in % Deviation; Simple To Operate For Rapid Production Checks. Price $400.00.

Wide Range Resistance Bridge

The Model 605 wide range resistance bridge provides a means for rapidly and easily checking resistances to a high degree of accuracy. Seven ranges for full scale resistance values are selectable by front panel push button switches. Features: 5 ohms to 100 megohms, push button operation, high accuracy, negligible drift.

Brief Specifications: Resistance Scales—100, 1K, 10K, 100K, 1M, 10M, 100M, Full Scale; Accuracy—± (.15% of resistance measured + .05% Full Scale); Drift—Negligible after 30 minute warm-up; Batteries—1-45 Volt, 2-7½ Volt; Price—$170.00.

Berkeley Double Pulse Generators

Model 4904 Double Pulse Generator

BRIEF SPECIFICATIONS	Model 903	Model 4904
Pulse Width:	0.15 to 1.8 μsec	0.3 to 10 μsec
Rise Time:	0.035 μsec	0.08 μsec
Decay Time:	0.15 μsec	0.26 μsec
Pulse Spacing:	0 to 10 μsec. Single control	0 to 100 μsec. Coarse and fine adjustments
Price:	$498.00	$645.00

Produce paired or single pulses. Pulse amplitude, width, polarity, repetition rate and pulse-to-pulse spacing are independently adjustable. Outputs may be mixed internally or externally. Model 903 can be driven externally by pulses; Model 4904 by pulses or sine wave generators.

APPLICATIONS

Measurement of paired pulse resolution time of counting circuits. Measurement of rise time, decay time and transient response of pulse forming circuits, electronic switches, gates and wide band amplifiers. Calibration of input sensitivity of counting instruments. Frequency calibration of counting rate meters. Measurements of overload characteristics and dynamic range of pulse amplifiers. Delayed coincidence work.

New *EASE** 1100 Series Analog Computers

The 1100 Series introduces a digital output-input translator system (DO/IT) that uses punched tape to set up and check problems, taking much of the human element out of computing and saving hours of operating time. Other new features include automatic static or dynamic problem checking, complete pushbutton monitoring system, and a fully shielded, color-coded patch board. Patch bay capacity 2188 to 3,600 terminals.

A typical setup would include:

- ★ **100 dc amplifiers**
- ★ **16 servos**
- ★ **300 DO/IT controlled attenuators**
- ★ **30 electronic multipliers**
- ★ **250 spare terminals**
- ★ **Required number of trunk lines and terminals for limiters, biases, etc.**

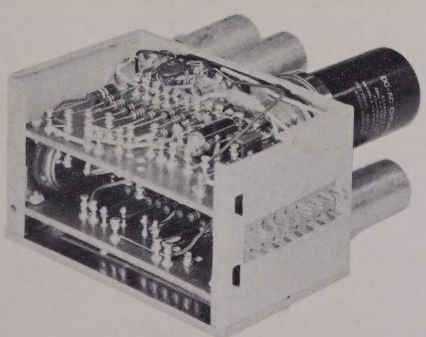
Computing resistors are maintained at an accuracy of better than .005% in a temperature controlled oven. Long-term accuracy of capacitors exceeds .05%. New servo-set potentiometer system permits adjustment of 50K Helipot precision potentiometers to an accuracy of better than 0.01% in less than 3 seconds average time.

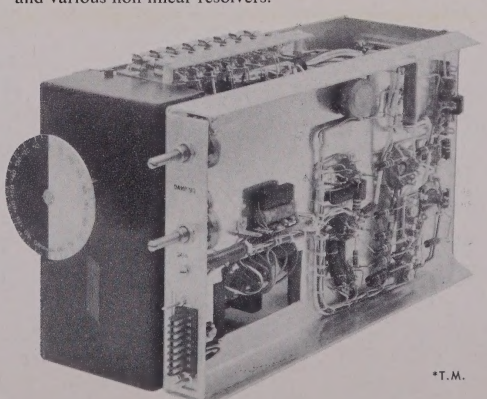
*EASE** Precision Components for Control Systems

Model 1191 General Purpose Servo Multiplier

Up to five variables are multiplied by a sixth in the Model 1191 Servo Multiplier. One, two, or three of the five computing potentiometers can be supplied as sine-cosine resolvers. Amplifiers are removeable for ease of maintenance. The front panel contains servo gain and damping controls, as well as servo error light and a shaft position indicator.

No dither is employed, thus minimizing potentiometer wear. Selection of internal or external feedback reference is made through a relay. Servo Multipliers can also be supplied with such special features as a synchro or one extra potentiometer mounted on the potentiometer shaft, additional taps up to 33 total per potentiometer, and various non-linear resolvers.

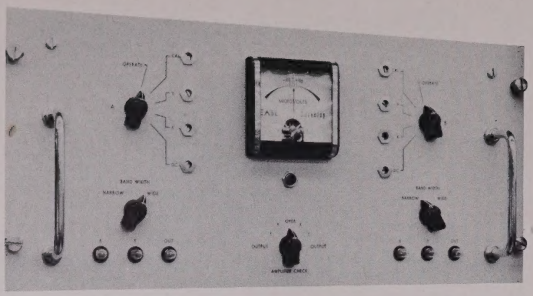




Model 1048B DC Amplifier

This new version of the Model 1048 amplifier, which has become a standard component for industry, features higher out-put current (better than 20 ma) and premium tubes with redesigned circuits for increased tube life.

*T.M.



Model 1157 High Accuracy Electronic Multiplier

Features .02% static accuracy on each of two independent products. Its chopper-stabilized amplifiers are available as inverters and its operation is switched by relay from multiplication to division. Two ranges are available—high accuracy, with a 10KC carrier, and wide band, with a 40KC carrier. This extends the usefulness of the multiplier well beyond the limitations imposed by a single compromise frequency carrier.

Specifications on other 1100 Series components and technical data on the complete computer are available on request. Prices on computer systems may be obtained by writing Sales Manager, Computer, Berkeley Division of Beckman Instruments, Inc., Richmond 3, California.

Customer Services From Beckman/Berkeley

Technical information on all instruments and applications data will gladly be supplied on request. There is no charge or obligation for this service. All literature is prepared by a staff of technical writers who work closely with Berkeley research and applications engineers. Recent literature includes:

Data File 110—FERRISTORS*, Their Use and Application
Data File 111—How to Make Frequency Measurements
Data File 112—How to Make Time Interval Measurements
Data File 10—How to Make WWV Measurements
Data File 123—Analog Computer Solutions for Feedback Control Systems

Beckman/Berkeley Representatives

Berkeley's world-wide staff of factory trained engineering representatives work closely with our sales office and the customer. They help the customer set up newly-purchased equipment, acquaint personnel with its operation and application, and make sure that it stays in operating order. The representative's job is not completed until he has "followed-up" to insure that the customer receives maximum use from his instruments. These men will be glad to give you personal assistance at any time. A list of Berkeley representatives follows.

ALBANY, NEW YORK
Edward A. Ossmann & Associates
16 Caveson Lane
Phone: Union 9-7081

ALBUQUERQUE, NEW MEXICO
V. T. Rupp Co.
8009 Bellamah, N.E.
Phone: Albuquerque 9-4621

ATLANTA 9, GEORGIA
Murphy & Cota
2110 Peachtree St., N.W.
Phone: Trinity 6-300

BINGHAMTON, N. Y.
Edward A. Ossmann & Associates
147 Front St., Vestal, N. Y.
Phone: Endicott 5-0296

BOSTON, MASSACHUSETTS
Broger Instrument Sales Co.
48 Pearl St., Brookline, Mass.
Phone: Beacon 2-4804

CHARLOTTE, NORTH CAROLINA
Murphy & Cota
2036 Norton Rd.
Phone: Edison 2-7356

CHICAGO 39, ILLINOIS
Ridgeway Engineering Assoc.
6100 W. North Ave.
Phone: Tuxedo 9-5715

CLEVELAND 28, OHIO
J. R. Dannemiller Assoc.
3955 Lee Road
Phone: Longacre 1-4567

DALLAS 9, TEXAS
John A. Green Co.
6815 Oriole Drive
Phone: Fleetwood 2-9918

DAYTON 2, OHIO
J. R. Dannemiller Assoc.
384 W. First St.
Phone: Hemlock 0662

DENVER, COLORADO
F. Y. Gates Co.
4910 South Huron
Englewood, Colorado
Phone: Sunset 1-8566

DETROIT, MICHIGAN
J. R. Dannemiller Assoc.
1204 North Woodward
Royal Oak, Michigan
Phone: Lincoln 8-4440

HONOLULU 17, HAWAII
Gene Piety
2030 Home Rule St.
Phone: 8-3105

HOUSTON 6, TEXAS
John A. Green Co.
P.O. Box 6445
(Fairview Station)
Phone: Jackson 6-2959

INDIANAPOLIS 2, INDIANA
Ridgeway Engineering Assoc.
1606 N. Illinois St.
Phone: Walnut 5-6464

KANSAS CITY 14, MO.
Leemark Associates
706 E. 73rd St.
Phone: Jackson 3-9299

LOS ANGELES, CALIFORNIA
V. T. Rupp Co.
305 Parkman Ave.
Phone: Dunkirk 7-8224

MIAMI 43, FLORIDA
Murphy & Cota
11375 S.W. 46th St.
Phone: Mohawk 5-1563

MINNEAPOLIS 3, MINNESOTA
Pinkney & Hine
1925 Nicollet Ave.
Phone: Federal 8-0523

NEW HAVEN 10, CONNECTICUT
Broger Instrument Sales Co., Inc.
42 Church Street
Phone: Spruce 7-6279

PHILADELPHIA, PENNSYLVANIA
Gawler-Knoop Co.
835 Glenside Ave., Wyncote, Pa.
Phone: Waverly 7-1820

PORTLAND 14, OREGON
Hawthorne Electronics
700 S. E. Hawthorne Blvd.
Phone: Belmont 4-9375

ROCHESTER 10, NEW YORK
Edward A. Ossmann & Assoc.
830 Linden Ave.
Phone: Hillside 5-0460

NEW YORK, NEW YORK
Gawler-Knoop Co.
178 Eagle Rock Ave., Roseland, N. J.
Phone: New Jersey, Caldwell 6-4545

ST. LOUIS 17, MISSOURI
Leemark Associates
1500 Big Bend Blvd.
Phone: Mission 7-1470

SALT LAKE CITY 1, UTAH
Gates Company
200 South Main St.,
Phone: Elgin 9-1101

SAN DIEGO 4, CALIFORNIA
V. T. Rupp Company
3948 Utah St.
Phone: Cypress 6-0483

SAN FRANCISCO, CALIFORNIA
Berkeley Division, Beckman Inst.
2200 Wright Ave., Richmond
Phone: Landscape 6-7730

SEATTLE, WASHINGTON
Hawthorne Electronics
107 Administration Bldg.
Boeing Field
Phone: Mohawk 3962

SYRACUSE, NEW YORK
Edward A. Ossmann & Associates
308 Merritt Ave.
Phone: Howard 9-3825

TULSA 1, OKLAHOMA
John A. Green Co.
P.O. Box 911

WASHINGTON, D. C.
Gawler-Knoop Co.
8726 Colesville Road,
Silver Spring, Md.
Phone: Juniper 5-7550

WINSTON-SALEM, NO. CAROLINA
Murphy & Cota
1102 Burke St.
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107 Administration Bldg.
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MONTREAL, QUEBEC
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Phone: Dexter 0845

TORONTO, ONTARIO
R-O-R Associates
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*T.M.